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# INDUSTRIAL SOLID WASTE CLASSIFICATION SYSTEMS

ARTHUR D. LITTLE, INCORPORATED

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A classification system for industrial processing wastes was developed based on waste stream characteristics, materials components, and chemical composition. An associated inventory form was devised for systematic reporting of a variety of waste descriptors including physical form, composition, methods of handling, treatment and disposal, and potential for reuse. The system was developed by literature review, consultations, and site visits. It is intended for application to industrial waste surveys and to the preparation of statistical summaries of parameters pertinent to solid waste management. The system is adaptable to computer storage and retrieval of information related to reuse potential and disposability of industrial wastes. It is designed to cover all industries of the SIC codes, and has been tested on a broad representation of processing waste streams in a large number of industries.

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# FOREWORD

Man and his environment must be protected from the adverse effects of pesticides, radiation, noise and other forms of pollution, and the unwise management of solid waste. Efforts to protect the environment require a focus that recognizes the interplay between the components of our physical environment--air, water, and land. The National Environmental Research Centers provide this multidisciplinary focus through programs engaged in

- studies on the effects of environmental contaminants on man and the biosphere, and
- a search for ways to prevent contamination and to recycle valuable resources.

The research efforts described herein represents the development of a classification system for industrial processing wastes based on waste stream characteristics, materials components, and chemical composition. It is designed to cover all industries of the SIC codes, and has been tested on a broad representation of processing waste streams in a large number of industries.

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## Abstract

A classification system for industrial processing wastes was developed based on waste stream characteristics, materials components, and chemical composition. An associated inventory form was devised for systematic reporting of a variety of waste descriptors including physical form, composition, methods of handling, treatment and disposal, and potential for reuse. The system was developed by literature review, consultations, and site visits. It is intended for application to industrial waste surveys and to the preparation of statistical summaries of parameters pertinent to solid waste management. The system is adaptable to computer storage and retrieval of information related to reuse potential and disposability of industrial wastes. It is designed to cover all industries of the SIC codes, and has been tested on a broad representation of processing waste streams in a large number of industries.

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# SUMMARY

## DEVELOPMENT OF AN INDUSTRIAL WASTE CLASSIFICATION SYSTEM

### Information Survey

In order to establish a useful classification system, data on the generation and disposal of industrial processing wastes were obtained through a literature review, personal interviews, and plant visits. It was found that the diversity of wastes generated by industry is at least as great as the diversity of products, and that there are many dimensions along which the wastes might justifiably be classified, including, singly or in various combinations:

1. Waste stream characteristics
2. Physical form
3. Material constituents
4. Chemical composition
5. Unit process origin
6. Waste treatment process used
7. Method of handling
8. Mode of transport to treatment/disposal site
9. Receiving entity
10. Final disposal method

### Classification System Specifications

The materials based classification system commonly used for municipal wastes is inadequate to cover many industrial processing wastes, particularly the sludges, slurries, tars, and organic and inorganic chemicals which fall into the hazardous waste category. In previous work, a classification system for hazardous wastes developed by ADL defined eight waste categories requiring similar types of treatment and disposal, to which may be appended code numbers for specific hazardous components. However since hazardous wastes constitute only about 10% of industrial processing wastes, to cover the full range of industrial wastes, a hybrid approach was developed involving classification by waste stream characteristics-materials constituents- and specific chemical composition, where necessary. Twenty-nine processing waste streams were defined and coded as follows:

Solid Waste Streams

| Code | Description |
|---|---|
| 10 | Obsolete or discarded hardware and equipment (metal) |
| 11 | Machine shop waste (metal) |
| 12 | Metal dross |
| 13 | Other metal |
| 20 | Plastics (other than packaging) and rubber |
| 30 | Wood (other than packaging) |
| 31 | Paper (other than packaging) |
| 40 | Textiles (other than packaging) |
| 50 | Mining and mineral tailings |
| 51 | Fly ash |
| 52 | Slag |
| 60 | Manure |
| 61 | Dead animals |
| 62 | Animal remains (other than manure) and biological tissue |
| 63 | Leather |
| 65 | Filter cakes containing natural organic compounds mixed with inorganic solids |
| 66 | Pharmaceuticals |
| 70 | Vegetative remains |
| 82 | Inorganic solids (other than inerts), filter cakes, wet cakes, and sludges containing less than 50% water |
| 84 | Wet cakes, slurries, and sludges (including sewage or treatment sludge) containing both synthetic organics and inorganics |
| 85 | Other waste streams containing synthetic organic compounds mixed with inorganic solids |
| 86 | Solid organics, including tars |

Liquid Waste Streams

| Code | Description |
|---|---|
| 87 | Non-aqueous liquid streams containing organics |
| 80 | Aqueous streams containing inorganic compounds in solution |
| 81 | Inorganic aqueous slurries, slimes, and sludges containing more than 50% water |
| 83 | Aqueous streams containing both inorganics and organics in solution |
| 88 | Aqueous streams containing synthetic organics, including oils, soaps or detergents |
| 64 | Aqueous streams containing proteins, fats, and/or carbohydrates derived from plant or animal products |

Gaseous Waste Streams

| Code | |
|---|---|
| 86 | Stack gases |

Nine categories of materials constitutents were defined as follows:

| | |
|---|---|
| 10000 | Metals |
| 20000 | Resins, Plastics, Rubbers |
| 30000 | Wood and Paper Materials |
| 40000 | Textiles and Related Fibers |
| 50000 | Inert Materials |
| 60000 | Animal Product Wastes |
| 70000 | Vegetative Product Wastes |
| 80000 | Chemical and Biochemical Wastes |
| 90000 | Miscellaneous Common Waste Mixtures |

A five digit code number was selected to permit hierarchical subcategorization, as shown in Chapter IV, Section A-3, Table V.

Finally, for waste streams containing inorganic or organic chemical constituents, a further classification by chemical compound was developed. The organic chemicals coded include both the hazardous chemicals listed by TRW in their hazardous waste studies, and those listed by the Coast Guard in their CHRIS manual.

The basic classification format would then be:

| Waste Stream | Materials Components | Chemical Compounds |
|---|---|---|
| - - | - - - - -<br>- - - - - | - - - - |

The first two digits describe the waste stream generically. The next five digit listing would give materials components present in the waste stream. Every materials component with a first digit of 8 (Chemical and Biochemical Wastes), would in general be classified further in accordance with specific chemical compounds present (particularly hazardous compounds).

## APPLICATION OF THE CLASSIFICATION SYSTEM TO SELECTED INDUSTRIES

The classification system developed was shown to be applicable to solid waste data available in the literature, and was further tested in plant visits. Data reported in the literature is frequently restricted to wastes which are truly solid in the physical sense. By using a more broadly based waste stream classification, and by providing coded check lists of a wider range of waste constituents (Ref. Chapter IV, Section A-3), we found that plant managers would often acknowledge generating certain types of wastes that they had failed to mention in initial discussions. This was particularly the case with chemical wastes, which often constitute a small volume of the total waste load for a plant, but which we know to have a significant environmental impact.

## IMPLEMENTATION OF THE CLASSIFICATION SYSTEM

In order to implement the classification system, for statistical reporting and other purposes, classifiable data must be obtained on industrial processing wastes. An inventory form was therefore developed (Ref. Chapter IV) for systematically recording the necessary information. Most plant managers indicated that they had the data available, although not always immediately at hand. On the basis of the inventory form, a field manual can be prepared. After completion of the form with the plant manager, the field interviewer should diagram the flow of waste materials from the points of generation, through treatment processes (if any), to ultimate disposal. Depending upon the specific purpose of the field work, critical points for sampling and analysis of waste streams may be flagged. Due to the intermittent nature and variable composition of some of the waste streams, grab samples should generally be taken at several points in the waste stream and at several different times. Industrial processing wastes, unlike municipal wastes, can and should be sampled at the point of generation, where they tend to be relatively homogeneous. If in fact, a number of wastes are mixed prior to disposal, this will be clear from the completed inventory form. The composition of the mixture is best calculated from an analyses of individual wastes and observation of the fraction of the total mixture contributed by the individual wastes. Direct analysis of the mixture is less desirable due to the problems of statistical sampling and the increased number of steps required for complete analysis, the more components the mixture contains.

# CHAPTER I. INTRODUCTION

The diversity of solid wastes generated in the industrial sector of the economy is at least as great as the diversity of products manufactured. The program discussed in this report has been aimed at the development of a detailed, practical, systematic classification system universally applicable to all solid wastes generated by industries in every division of the SIC codes. Within the context of this report "solid" waste refers to any waste, regardless of its physical form, which is not legally discharged into the air or the water.

"Waste", strictly speaking, is superfluous or rejected matter which is thrown away or discharged as worthless. Thus, by-products, rejected matter which is sold to secondary materials dealers, and which is therefore not worthless, and any portion of a plant's output which is reused or recycled within the plant are not really "wastes", and should not be classified as such. On the other hand, salvage, reuse, recycling, and reclamation are very much a part of the science of "solid waste management". Since a comprehensive waste classification system should ideally encompass all aspects of industrial waste management, we will define "waste" in this report to mean any output from an industrial establishment which is considered to have no value within the ordinary or main activities of that establishment. A more accurate term, which has not found universal acceptance in the literature, is "residuals".

For purposes of classification, industrial wastes are conveniently divided into three categories: (1) non-process wastes, which are common to all industries and which are similar in character to municipal wastes, (2) packaging wastes, and (3) process wastes, which are peculiar to each industry by virtue of the raw materials processed and/or the products produced. The non-process wastes would typically include: office wastes (primarily paper, mixed with assorted apple cores, partially eaten sandwiches, soda bottles and cans, cigarette and cigar butts, plastic holders that held transparent tape, etc.); construction and demolition debris; grass clippings and tree prunings (for establishments located in industrial park-type settings); external maintenance wastes (yard and street sweepings); internal maintenance wastes (light bulbs, telephone wire, dustrags, floor sweepings, obsolete office equipment, etc.); and cafeteria wastes (paper and food). The solid waste classification systems in the literature for municipal refuse should serve equally well for non-processing industrial wastes, and for the most part, the quantities generated in industry should be scaled by the number of employees.

Packaging wastes from industrial establishments are often contaminated by the raw materials used in processing. Such contamination both limits the potential for reuse and recycling, and complicates ultimate disposal if the contaminants are in any way hazardous. The reason for categorizing packaging wastes separately from processing wastes is that in many companies, perhaps even in most, packaging wastes represent a very significant fraction (sometimes 90%) of the total processing wastes. As a consequence, manufacturing companies (SIC Codes 20-39), when queried about their processing wastes, sometimes tend to confine their response to packaging wastes. In cases where the total tonnage of packaging wastes requiring disposal greatly exceeds the quantities of other processing wastes, this practice may not be deliberately deceptive (although sometimes it admittedly is). On the other hand, it is the wastes generated in basic material processing and product manufacturing which often present the greatest potential for salvage, and the most troublesome disposal problems where salvage is impractical. It is, for example, among the various industrial sludges, slurries, tars, oily liquids, solvents, filter cakes, and miscellaneous gunks and goos, that most of the potentially hazardous wastes are found, wastes which are often either unacceptable for landfill and/or difficult to incinerate. While the quantities of such wastes generated in any given establishment tend to be relatively small, they can have a disproportionately large adverse impact on the environment if not handled by the most sophisticated of solid waste management technology.

Roughly 4.4 billion tons of solid waste are generated in the U.S. annually.(1) Over half (2.3 billion tons/yr) is agricultural and animal wastes (mostly manure), and almost 40% (1.7 billion tons/yr) are the residuals from mining and mineral processing. About 5.7% of the total (0.25 billion tons/yr) is municipal waste. Industrial processing wastes, outside of the farming and mining sectors, represent only about 2.5% of the annual waste production in the country. However, 2.5% is still 110 million tons/yr, and as indicated earlier, these are the wastes which are most amenable to control. Furthermore, about 10% of the wastes in this grouping (10 million tons/yr) fall into the hazardous category. About 4 million tons/yr are inorganic hazardous materials, and 6 million tons/yr are organic hazardous wastes, all requiring some form of safe land disposal, although 90% of these wastes occur as liquids or semi-liquids.

Solid waste classification, which is intimately related to solid waste inventory, is a prerequisite to the logical development of any solid waste management plan for industry. The form of the classification system, and the level of detail incorporated into the associated inventory, depends to some degree on the aims and purposes of the planner or the the planning entity. A number of classification systems, developed for specific applications, are discussed in Chapter II. Chapter III lays the foundations for a universal, multipurpose solid waste classification system and comprehensive waste inventory, which permits retrieval of data in a variety of forms to meet particular user needs. In Chapter IV, two alternative types of inventory forms are presented, suitable for obtaining classifiable solid waste management information. To facilitate complete and uniform response to the forms, a detailed series of check lists is provided to make explicit the kind of data required. Most of the plant managers who reviewed the forms and agreed they were comprehensive. In Chapter V, available literature on intra industry solid waste management practice is reviewed in order to determine the degree to which the universal classification system developed is capable of (1) reflecting everything that interested parties might ever want to know about solid wastes and (2) pointing up important questions pertinent to solid waste management that perhaps no one has dared to ask. Chapter VI summarizes the plant visits and interviews that were conducted during the course of the study to aid in the development of a generalized waste classification system, and to test its practicability and utility. In Chapter VII recommendations are made for using the results of this study in developing strategies for industrial solid waste management planning at the level of the plant, the industry, the municipality, the state and Federal government.

# REFERENCES

## CHAPTER I

1. Battelle Research Outlook, What's Ahead in Solid Waste Management, 3, (3), 1971.

# CHAPTER II. REVIEW OF WASTE CLASSIFICATION SYSTEMS FOR SPECIFIC APPLICATIONS

## INTRODUCTION

In reviewing the literature, we encountered no truly comprehensive classification encompassing the entire range of industrial solid waste management practice. Most of the literature is concerned with some aspect of waste management, and classification concepts are presented as they relate to specific problems of interest.

## MATERIALS CLASSIFICATION FOR MUNICIPAL WASTE

Most of the solid waste classification systems in the literature have been based on the sampling and analysis of municipal refuse, usually deposited in containers and collected from households and small commercial establishments (markets, hospitals, hotels, restaurants, offices, stores, etc.). In general, the wastes are subdivided into ten materials categories as indicated in Table I. Municipal wastes have been sampled and analyzed fairly extensively, and the results shown in Table I on a "Yard Waste-Free, As-Fired" basis have been obtained rather consistently throughout the nation. The yard waste-free basis is used to eliminate the highly seasonal effects of "yard wastes" on the totals. "As-Fired" wastes are to be distinguished for "As-Discarded" wastes which may lose or absorb moisture. The "As-Fired" basis takes into account moisture transfer phenomena.

The non-processing wastes generated by industry would not be expected to deviate very much for the average compositions of municipal waste as given in Table I, and certainly would be expected to lie within the relatively narrow 95% confidence range for each component.

The materials classification given in Table I for municipal wastes, however, is totally useless for the classification of industrial processing wastes, particularly that segment of the waste load which represents a potential hazard to human health or living organisms if not handled and disposed of properly.

Unfortunately, most surveys of industrial solid wastes have concentrated on wastes which are true solids in the physical sense, while most of the hazardous processing wastes are sludges, slurries, or liquids. Furthermore, while a fair amount of effort has been devoted to the removal of hazardous substances, particularly toxic substances, from industrial aqueous and gaseous effluent streams, it is only beginning to be recognized that the substances removed may still exert harmful effects on the environment if they are ultimately disposed of by landfill or incineration. Of course, many of the potentially hazardous wastes generated as a result of industrial processing never find their way into aqueous or gaseous effluent streams, but may be land-filled or incinerated directly with highly detrimental effects. Flammable wastes, for example, which consist of such things as contaminated organic solvents, oils, pesticides, plasticizers, complex organic sludges, and off-specification chemicals, can pose acute handling and chronic disposal problems. There have been many fires in landfills for instance, due to careless disposal of wastes of this kind.

## WASTE STREAM AND MATERIALS CLASSIFICATION FOR HAZARDOUS WASTES

A hierarchical hazardous waste classification system, based on components present in the waste stream, was developed by Arthur D. Little, Inc.(1) in connection with another program and is given in Table II. This type of system, while useful for some purposes, is deficient in failing to describe either the physical form of the components or the nature of the waste stream in which such components might be found. To overcome these deficiencies another level of waste stream categorization as indicated in Table III may be applied, related to the kinds of treatment processes that might be used prior to ultimate disposal. As practical classification procedure, illustrated in Table III would involve first specification of waste stream category by letter, and the identification of each hazardous waste stream constituent by one to three symbols, depending upon the level of detail required.

## STREAM, MATERIALS, AND PROPERTY CLASSIFICATION OF WASTES FOR DISPOSAL

Classification of wastes by material constituents is inadequate for the purpose of evaluating the disposability, hazard potential, and recycling potential of wastes as they occur in mixtures. At a minimum, therefore, it is necessary to classify both industrial waste streams, as they exit from the plant boundaries, as well as the specific components of those streams. It may be useful to further classify the waste streams and/or their components with respect to physical, chemical, and biological properties that relate to the development of safe and efficient handling, treatment, and disposal technology. For example, the streams might be classified by the type(s) of hazard that they present for handling, storage, and/or disposal. A possible categorization system for hazardous attributes is given in Table IV.

Properties that relate to the suitability of a waste for incineration (with or without heat recovery) are listed in Table V, and constitute possible classification dimensions.

## OTHER BASES FOR CLASSIFICATION

Hierarchial classification of wastes by stream - material constituents - properties is one general approach to collecting and organizing solid waste data in a form that is useful for many aspects of industrial solid waste management.

Many other types of classification systems have been reported in the literature (1-41). Most are materials oriented. Some are based on industrial process origins. Others are based on physical form (solids, wet semi-solids, tars, sludges, non-pumpable liquids, pumpable liquids). In many systems, a mixed list of categories is defined, some of which relate to waste stream characteristics, others to materials constituents, still others to physical form. In some work, wastes are classified by actual or potentially applicable waste disposal/recovery processes. Resource recovery potential and hazard potential provide two other primary bases for classification.

## Table I: Materials Classification of Municipal Refuse

| Materials Categories | Mean Wt. Percent Yard Waste-Free As-Final Basis | 95% Confidence Range |
|---|---|---|
| Paper | 50.7 | 46.6 - 56.6 |
| Metal | 10.0 | 9.3 - 11.1 |
| Ferrous | | |
| Major Non-Ferrous (Al, Cu, Zn, Pb) | | |
| Wood | 2.9 | 1.9 - 4.1 |
| Glass | 9.7 | 8.0 - 11.8 |
| Textiles | 2.6 | 1.8 - 3.6 |
| Plastics | 1.4 | 0.7 - 2.1 |
| Rubber and Leather | 1.9 | 0.7 - 3.2 |
| Food Wastes | 19.1 | 14.6 - 24.0 |
| Miscellaneous | 1.7 | |
| Yard Wastes | | |

Table II: Chemical Classification of Hazardous Waste Stream Constituents

| Category | Sulcategory | Specific Chemical Compounds |
|---|---|---|
| I. Antimony Compounds | - | $SbF_5$ |
| | | $SbF_3$ |
| II. Arsenic Compounds | A. Arsenates | 1. Ca |
| | | 2. Cu |
| | | 3. Pb |
| | | 4. Mn |
| | | 5. Na |
| | | 6. Zn |
| | B. Arsenites | 1. Ca |
| | | 2. Copper aceto |
| | | 3. Pb |
| | | 4. K |
| | | 5. Na |
| | | 6. Zn |
| | C. Other | 1. $AsCl_3$ |
| | | 2. $As_2O_3$ |
| III. Cadmium and Compounds | A. Soluble | 1. Cl |
| | | 2. $NO_3$ |
| | | 3. $SO_4$ |
| | B. Insoluble | 4. CdO |
| | | 5. Cd metal |
| | | 6. $Cd_3(PO_4)_2$ |
| IV. Cyanides | A. Soluble | 1. Na |
| | | 2. K |
| | B. Insoluble | 1. Cu |
| | | 2. Zn |
| | | 3. Cd |
| | | 4. K |
| | | 5. Pb |
| | | 6. Hg(II) |
| | | 7. Ag |
| | | 8. Ca |
| | | 9. Ni |
| V. Chromium Compounds | A. Soluble Chromates/ Dichromates | 1. $NH_4$ |
| | | 2. K |
| | | 3. Na |
| | | 4. Chromic acid |
| | B. Cr(III) sludges | 1. F |
| | | 2. $SO_4$ |
| | | 3. CN |
| VI. Mercury and Compounds | A. Metal | |
| | B. Organo mercury | |
| | C. Inorganics | 1. Cl |
| | | 2. $NO_3$ |
| | | 3. $SO_4$ |
| | | 4. $NH_4Cl$ |

Table II (Continued)

| | | |
|---|---|---|
| VII. Other Inorganics | A. Carbonyl | 1. Nickel |
| | B. Interhalogens | 1. $BrF_5$ |
| | | 2. Perchloryl fluoride |
| | | 3. $ClF_3$ |
| | | 4. $F_2$ |
| | | 5. $Cl_2$ |
| | | 6. COCl |
| | C. Miscellaneous | 1. $H_2S$ |
| | | 2. Diborane |
| | | 3. Pentaborane |
| VIII. Pesticides | A. Chloroorganics | 1. Aldrin |
| | | 2. Benzene hexachloride |
| | | 3. 2,4-D |
| | | 4. DDD |
| | | 5. DDT |
| | | 6. Dieldrin |
| | | 7. Endrin |
| | | 8. Heptachlor |
| | | 9. Chlordane |
| | B. Organic Phosphates | 1. Demeton |
| | | 2. Guthion |
| | | 3. Methyl Parathion |
| | | 4. Parathion |
| | C. Nitro Compounds | 1. Dinitrocresol |
| IV. Miscellaneous Organics | A. Aliphatic Halogens | 1. $CCl_4$ |
| | | 2. $CHCl_3$ |
| | | 3. Dichlorofluoromethane |
| | | 4. Dichloroethyl Ether |
| | | 5. 1,2-Dichloropropane |
| | | 6. 1,3-Dichloropropene |
| | | 7. Dichlorotetrafluoroethane |
| | | 8. Ethyl Chloride |
| | | 9. Ethylene Dichloride |
| | | 10. Methyl Chloroformate |
| | | 11. Perchloroethylene |
| | | 12. Tetrachloroethane |
| | | 13. Trichloroethane |
| | | 14. Trichloroethylene |
| | | 15. Trichlorofluoromethane |
| | | 16. Vinyl Chloride |
| | B. Aromatic Halogens | 1. Chloroacetophenone |
| | | 2. Chlorobenzene |
| | | 3. o-Dichlorobenzene |
| | | 4. p-Dichlorobenzene |
| | | 5. Trichlorobenzene |
| | | 6. Hexachlorophene |
| | C. Organo Lead | 1. Tetramethyl Lead |
| | | 2. Tetraethyl Lead |

Table II (Continued)

| | | |
|---|---|---|
| | D. Other | 1. Acrolein |
| | | 2. Dimethyl Sulfate |
| | | 3. Dinitro Toluene |
| X. Explosives | A. Liquid Nitrate Esters | 1. Nitroglycerin |
| | | 2. Glycol Dinitrate |
| | B. Solid Nitrate Esters | 1. Dipentaerythritolhexanitrate |
| | | 2. Gelantinized Nitrocellulose |
| | | 3. Mannitol Hexanitrate |
| | C. Aromatic Nitro Compounds | 1. Picric Acid |
| | | 2. Furoxan (KDNBF) |
| | D. Initiators | 1. Lead Styphnate |
| | | 2. Tetrazene |
| | | 3. Diazodinitrophenol (DDNP) |
| | E. Heavy Metal Salts | 1. Copper Acetylide |
| | | 2. Silver Acetylide |
| | | 3. Silver Azide |
| | | 4. Mercury Fulminate |
| | | 5. Lead Azide |
| | | 6. Cyanuric Triazide |
| | F. Primers and Detonators | |
| XI. Radioactive | A. Wastes from Nuclear Reactors | |
| | B. Other (limited) | 1. Cobalt-60 |
| | | 2. Iridium-192 |
| | | 3. Krypton-85 |
| | | 4. Zenon-133 |
| | C. Other (widely used) | 1. Carbon-14 |
| | | 2. Iodine-129, 131 |
| | | 3. Radium |

## Table III: Hazardous Waste Stream Categorization

| Code | Stream Category | Description | Table II Wastes That May Be Present |
|---|---|---|---|
| A | Concentrated Heavy Metals | Aqueous streams with heavy metal concentrations >0.1% | I, II, III, V, VI-C |
| B | Dilute Heavy Metals | Aqueous streams with heavy metal concentrations <0.1% | I, II, III, VI-A, C |
| C | Dilute Heavy Metals with Organics | Aqueous streams with metals and organics in solution | I, II, III, VI |
| D | Heavy Metal Sludges | Wet cakes, slurries, and sludges containing precipitated heavy metals | I, II, III, VI |
| E | Concentrated Cyanides | Waste streams containing more than 0.1% $CN^-$ | I, III, IV, V-B, VI-C |
| F | Dilute Cyanide | Aqueous streams with $CN^-$ concentrations <0.1% | I, III, IV, V-B, VI-C |
| G | Liquid Wastes with Chlorinated Hydrocarbons | Liquid streams that can be incinerated without pretreatment other than filtering | II-A, B; VIII, IX |
| H | Organic Wastes with Solids | Organic-containing waste streams requiring a rotary kiln incinerator | I, II-B,C; III, IV, V, VI, VII-A, C; VIII-A,B,; IX |

Table IV: Categorization of Hazardous Attributes of Waste Streams

| Hazard Category | Measure |
|---|---|
| Radioactivity | Isotopic constituents in the waste stream at levels greater than the maximum permissible concentrations set by the AEC |
| Bioconcentration | Waste constituents subject to concentration in the biological chain - heavy metals; persistent organics |
| Flammability | Waste stream falling into Category 4 of the National Fire Protection Association (NFPA) codes (flammable gases, flammable liquids with boiling points or flash points below 100°F; spontaneously combustible waste streams) |
| Reactivity | NFPA Category 4 reactive (tendency to detonate by electrostatic charge, oxidize, polymerize, explode, react violently with water or air) |
| Toxicity | Oral $LD_{50} < 50$ mg/kg<br>$LC_{50} < 200$ ppm as a vapor<br>$LC_{50} < 2$ mg/l as a dust<br>$LD_{50} < 200$ mg/kg by dermal penetration<br>Aquatic toxicity - 96 hours<br>$TL_m$ (media threshold limit) $< 1000$ ppm<br>Phytotoxicity - $IL_{50} < 1000$ ppm<br>($IL_{50}$ - concentration that reduce photosynthetic activity in a culture by 50% over a 14 day period) |
| Irritating | Dermal irritation reaction Grade 8 (Smyth or FDA methods) |
| Genetically Active | Carcenogenic, mutagenic, teratogenic |

## Table V: Properties Used to Evaluate the Behavior of Wastes in Incinerators

Physical Properties

- Density
- Flash Point
- Melting Point
- Viscosity

Chemical Properties

- Heat of Combustion (BTU content)
- % Ash
- % Chlorine
- % Moisture
- pH
- Vapor Pressure

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# III. FOUNDATIONS FOR A MULTIPURPOSE CLASSIFICATION SYSTEM

## INTRODUCTION

The two criteria that must be satisfied by any classification system are exclusivity and exhaustivity. An industrial solid waste classification system, then, should provide a one-to-one correspondence between the wastes generated as a result of industrial processing and the code number assigned to such wastes (exclusivity). Furthermore, the classification system should be designed so that a code number can be assigned to every type of industrial waste that can be encountered (exhaustivity).

There are many forms that an Industrial Solid Waste Classification System might usefully take, depending upon the purposes for which it is intended. Virtually all people involved in solid waste management in any way have probably developed a classification system for the wastes with which they are primarily concerned, if only for purposes of organizing their files. An Industrial Solid Waste Classification System will generally be required to provide a systematic basis for:

1. Identifying processing wastes which have recycle potential, and/or
2. Assessing the disposability of non-recyclable wastes, particularly those which are hazardous to handle and those which could be hazardous if sent to conventional landfill or incineration facilities

The types of information and the level of detail required to serve these very general needs differs enormously for specific applications. For example, the National Association of Secondary Materials Industries (NASMI) is concerned with the recycling potential of wastes only insofar as they have a marketable value. At present, only six categories of wastes meet the criterion of marketability: nonferrous metals, paper stock, cotton, synthetic fibers, wool, and shredded cans. Furthermore, not all of the wastes classifiable into one of these six categories are of interest to secondary materials dealers. NASMI has published very detailed specifications describing acceptable subcategories. The secondary materials industry is, of course, interested in expanding their markets. For this purpose, they would find a waste classification system based on "marketability" most useful, e.g., (0 = presently marketable; ...; 5 = potential market might develop over the next five years; ...; 9 = not marketable at all in the foreseeable future).

Others concerned with recycling have a very different point of view from the secondary materials industry in terms of the types of wastes that are of interest and the properties that are of primary importance. In the solvents recovery business, for example, there is only interest in liquid wastes which have a substantial organic component. In order to assess the acceptability of a liquid waste for recovery, a great deal must be known about it. A classification of even relatively pure liquids by primary component, for example, would be insufficient. From the point of view of solvents recovery, acetone contaminated with methanol is an essentially different waste from acetone contaminated with toluol. In addition to a detailed chemical analysis including basic constituents, the solvents recovery company must classify certain properties related to distillation behavior, including for example: density, pH, yield (or degree of recovery that can be achieved), non-volatile residue, boiling point, etc.

From the point of view of an individual plant, interest in recycling might encompass the two preceding examples. That is, most large industries are generally well aware of which of their solid wastes are in fact saleable scrap and which of their solvent wastes are recoverable. Economics, however, is usually of paramount importance in making a final decision on recycling vs. disposal. The costs of separating saleable and non-saleable paper, for instance, may not be balanced with the potential return from sales of scrap, even if disposal costs are thereby reduced. Whether it is economical to reuse solvents depends upon the sum of the costs of disposing of used solvents and buying virgin raw materials vs. the costs of recovery. The recycling interests of an individual plant, however, extend well beyond the sale of scrap and recovery of solvents. Manufacturing establishments are constantly concerned with improving their yields, decreasing the percentage of quality rejects, and increasing the efficiency of utilization of raw materials, all of which, if successful decrease the amounts of processing wastes generated for disposal. Classification of waste output as a function of product input for each step in the manufacturing process is often useful in identifying the major production problem areas. The physical, chemical, mechanical and other properties of the wastes might determine the possibilities for reprocessing within the plant, i.e., reconverting to a useful raw material for some part of the plant operation. Again economics is the driving force.

The possibilities for recycling potential wastes through the manufacture of by-products is of some interest within a given plant or industry, if the by-product can be made and marketed profitably. Many examples can be cited of by-products which have become such an integral part of an industry that they are never any longer even thought of as wastes. The increasing costs and burdens of providing for environmentally safe waste disposal will undoubtedly accelerate the search for potential by-products including energy recovery. Wastes cannot be classified with respect to their utility for conversion into by-products that have yet to be developed. A classification system can however provide information about the chemical composition, properties and quantities of waste materials available that might help to suggest productive areas of research into by-product manufacture. Similarly, the same kind of information, properly classified, might be used by imaginative entrepreneurs to evaluate opportunities for establishing new businesses based on solid waste utilization.

Another purpose, related to recycling, that might be served by an Industrial Solid Waste Classification System is the identification of waste materials from one industry that might be raw materials for another. Arthur D. Little, Inc., for example, helped to establish a total energy system for a private company, in which the solid wastes would be burned to supply the energy requirements of the plant. The quantity of wastes generated internally did not quite match the needs of the boiler, and it took some effort to locate a supplementary source of waste with the proper burning characteristics. If there had been a computerized bank of solid waste information available, classified by geographical location, material and BTU content, an appropriate waste source might have been located more easily.

Disposability, like recyclability, is not classifiable per se. We can, however, classify properties which relate to disposability so that the classification system can serve as a starting point for assessing waste disposal needs and developing waste disposal alternatives. In a broad sense, waste disposal encompasses all steps in the management of solid wastes from their points of generation to their points of ultimate disposition. It, therefore, would include handling, storage, transportation, intermediate treatment (e.g., incineration), and final disposal. One of the most important concerns in waste disposal is hazard potential. A hazardous waste classification system based on hazardous waste stream characteristics, hazardous components and properties relating to hazard's assessment, was discussed in Chapter II. Hazard potential is a highly significant determinant of the suitability of wastes for acceptance at landfills and/or disposal sites. A number of systems for classifying solid wastes with respect to their suitability for incineration are discussed in Appendix A, and two others -- one developed by the now defunct Cope, International, and the very sophisticated system developed by Dow Chemical -- are discussed in Chapter IV.

In general, the factors which affect disposability include: refuse composition, moisture content, BTU values (related to C, H, O, N, and S analysis), bulk density, refuse flow characteristics, volatile content, biodegradability, combustibility, ease of handling, degree of compaction, percentage of bulky items in the total waste output, toxicity, flammability, attractiveness to vectors, mobility in the environment, etc. The factors of primary importance to the operator of a centralized industrial waste incinerator will be different from the factors of major concern to operators of a sanitary landfill or to operators of a hazardous waste disposal facility.

## PRINCIPLES AND SYSTEMS FRAMEWORK FOR A UNIVERSAL CLASSIFICATION SYSTEM

We have discussed some of the many diverse issues of industrial solid waste management and a number of special purpose waste classification systems whose primary focus is related to those specific issues. In this report, we have tried to develop a universal classification system which incorporates some of the special purpose systems as retrievable subsets.

The basic principle of the classification system is a matrix containing several dimensions. Each vector of the matrix is itself a unique class of information. Within each vector, a master list of key words is developed and coded.

Table I contains a list of 21 dimensions covering the fundamental components of an industrial waste classification system. Any number of information systems can be developed based upon any appropriate combination of the dimensions listed and/or additional dimensions that may be deemed appropriate.

Each of the dimensions 1 through 21 may be thought of as classifiers. In searching an inventory derived from a large survey, or a library indexing system, one could specify the key words or codes of interest in each dimension. This would result in very precise retrieval of information relevant to the purposes of the system user. The various dimensions are discussed below, and a systematic industrial waste survey form, based on these dimensions, is developed in the next section. Means for storing and retrieving the information classified are covered in the section entitled, Statistical Reporting of Inventory Results.

## RECOMMENDED DIMENSIONS FOR INDUSTRIAL WASTE SURVEYS

### Geographic Locale

The national zip code system provides a most appropriate basis for referencing the geographic locale of industrial plants. An alternative scheme may be based upon location within the national river basin network. However, knowledge of zip code is virtually univeral, while knowledge of river basin location code is extremely limited. If the full five digits of the zip code are used, however, a computer program can readily be written which will transform zip code to river basin location code, if that system should prove more appropriate.

Location is a very important dimension of a solid waste classification system. The value of scrap varies from one part of the country to another. The planning of state, regional and/or federal hazardous waste disposal sites should be optimized with respect to the geographical distribution of plants generating such wastes. Furthermore, the possibilities, however remote, of interplant transfer of solid wastes (one plant's waste as another's raw material) are highly dependent on distance between plants and associated transportation costs.

## TABLE I

## DIMENSIONS OF THE CLASSIFICATION SYSTEM

| | | |
|---|---|---|
| 1. | GEOGRAPHIC LOCALE (ZIP) | standard reference |
| 2. | INDUSTRIAL GROUP ORIGIN (SIC) | standard reference |
| 3. | PLANT BOUNDARY REFERENCE | wastes entering plant - generated and consumed or disposed within plant - leaving plant |
| 4. | WASTE STREAM IDENTIFICATION | Table I - inventory coding |
| 5. | PHYSICAL FORM | Table II - inventory coding |
| 6. | MATERIAL CONSTITUENTS | Table III - inventory coding |
| 7. | CHEMICAL COMPOSITION | Table XI - inventory coding |
| 8. | UNIT PROCESS ORIGIN | Table IV - inventory coding |
| 9. | TREATMENT PROCESS ON SITE | Table IV - inventory coding |
| 10. | METHOD OF HANDLING | Table V - inventory coding |
| 11. | TRANSPORTATION MODE | Table VI - inventory coding |
| 12. | RECEIVING ENTITY | Table VII - inventory coding |
| 13. | METHOD OF FINAL DISPOSAL | Table VIII - inventory coding |
| 14. | HAZARD ATTRIBUTES | Table IX - inventory coding |
| 15. | INFORMATION CONTENT | plant and waste attributes included on the inventory form |

PROPERTIES RELATED TO:

16. RECYCLABILITY
17. DISPOSABILITY
18. MOBILITY
19. DECOMPOSIBILITY
20. TOXICITY
21. OTHER "SUITABILITY" INDICES

## Industrial Group Origin

The Standard Industrial Classification (SIC) system has been the basis for compiling and storing information on the economics of American industry for many years, and has provided the framework for classic Input/Output analysis of the nation's economy. A classic extension of this analysis has been made by Leontief(1) to include waste generation coefficients which relate waste generated to production input factors. Use of the SIC system, therefore, provides a convenient framework for studies of the economic impacts of any changes in waste generating characteristics.

## Plant Boundary Reference

Meaningful statistics on industrial waste must be related to plant boundaries. Wastes entering plants are usually secondary materials purchased from other industries. They must be appropriately identified if inter-industry transfer of secondary and waste materials is to be correctly measured. "Wastes" that are generated and consumed within a plant are not really wastes and there is some controversy about whether they should be included in a solid waste classification system. They do provide a measure of the degree of inplant recycling that takes place, but there is some ambiguity about process outputs which would fall in this category. Wastes generated and disposed of on-site are more clearly true wastes and need to be identified in order to measure the magnitude of resources which are potentially recoverable, but are presently being destroyed by incineration or other waste destruction methods. Wastes leaving the plant (terminal plant wastes) will place a management burden upon those receiving the wastes, and will have an environmental impact at their point of final disposal.

## Waste Stream Identification

In general, any industrial establishment will generate a number of distinguishable waste streams, each handled as a unit for the purposes of treatment and disposal.

## Physical Form

Industrial wastes may be classified as: solid, low viscosity liquid, tar, sludges-non-pumpable solid-liquid mixtures, slurries-pumpable solid-liquid mixtures, gas, aerosol. While ambiguities may occur, it is essential that all forms of industrial waste generated be accounted for. Occasional inconsistencies of judgment regarding physical form would not appear to invalidate statistical results.

## Material Constituents

Industrial waste streams are typically mixtures and composites of various materials. The degree to which the material constituents must be identified varies a great deal depending upon current waste disposal practice and potential waste management alternatives. A hierarchial system, which starts with nine very broad common-name waste categories and allows for successively more detailed sub-categories down to Chemical Compound designations, provides the necessary flexibility. A five digit code appears to suffice. The frist digit provides a major classification category, and subsequent digits provide appropriate levels of sub-categorization of waste materials. The following first digit groupings are intended to encompass all forms of waste generated.

| | |
|---|---|
| 10000 | Metals |
| 20000 | Resins, Plastics and Rubbers |
| 30000 | Wood and Paper Materials |
| 40000 | Textiles and Related Fibers |
| 50000 | Inert Materials |
| 60000 | Animal Product Wastes |
| 70000 | Vegetative Product Wastes |
| 80000 | Chemical and Biochemical Wastes |
| 90000 | Miscellaneous Common Waste Mixtures |

Item 90000 deserves special mention. This category includes a number of common mixtures, where the specific material composition is known to be largely a function of the source of the waste. For example, in reporting wastes from a plant cafeteria, it is sufficient to merely classify the material mixture as "cafeteria waste". While theoretically one loses a degree of material specificity in classifying some mixtures in this manner, certain practical problems in obtaining meaningful waste material information are solved, and the process of interrogating plant waste management practice is selectively simplified. Moreover, by classifying common waste streams as characteristic mixtures and composites, a net gain in statistical precision is obtained. Specifically, the cumulative error that would occur if each respondent gave his own estimate of the material composition of characteristic mixtures is likely to exceed the error of statistically estimating the composition from standard sampling data.

The classification scheme provides the most material-specific designations with respect to wastes that are generated in processing or production. The finest degree of material specification will be required in the 81000, 82000, and 83000 series. Most of the waste materials that can be considered potentially harmful to human beings, or pose a serious hazard to the environment will occur in these series and the system recognizes the need for further chemical classification (Table XI).

Thus the material constituency dimension of the classification system is a flexible instrument, employing within a hierarchial coding system very specific material specifications, or characteristic mixtures and composites of materials as they are generated as wastes. The coding system of Table III is merely illustrative, and will need to be refined prior to actual implementation of an inventory system.

## Chemical Composition

Most wastes in the 80000 series require further specification of chemical constituents, if their hazardous and other attributes are to be fully characterized.

Reference to Table XI shows that the chemical classification of most inorganic compounds is rather straightforward, since most of them can be expressed as combinations of appropriate anion and cation pairs. Thus, in most instances, the precise chemical composition can be accurately and readily described.

The precise classification of all organic materials that appear as waste poses considerable additional difficulties. Irving Sax, in his book, "Dangerous Properties of Industrial Materials", (Reinhold, 1968), lists over 12,000 common industrial and laboratory materials, most of which are organic compounds. One approach to classifying these materials is that used by Sax: simply list all of the compounds in alphabetical order. Ultimately, this may be the only comprehensive and totally inclusive expedient. However, many of these materials are very common in waste discharges, and many others will occur only as traces in larger mixtures of waste.

The major industries generating wastes which merit organic chemical classification include: chemical process industries, petrochemicals, and pharmaceuticals. While statistics are not presently available on the relative occurrence of all of these materials in waste streams, it would appear that most of them fall into a much smaller number of organic categories. The families listed in the 81000 series probably account for over 90% by weight of all organic wastes discharged. The organic compound combinations available in Table XI permit the expansion of this list to include most organic compounds, with a degree of chemical specificity sufficient for characterizing the hazardous and other waste management attributes.

## Unit Process Origin and Treatment Process On Site

A typical industrial plant has within its boundaries a number of locations and operations, each of which generate waste. With a four digit coding system, the origin of wastes are organized as follows (see Table IV).

| | |
|---|---|
| 1000 | Operations Related to Plant Production Management |
| 2000 | Operations Related to Plant Facilities and Services |
| 3000 | In Plant Waste Treatment and Conversion Processes |
| 4000 | Non-Plant Waste Sources |

The last category permits the specification of virtually any waste source, and effectively extends the classification system to universally include all non-industrial as well as industrial waste sources.

The 1000 and 3000 series are of primary interest in any information system that deals with industrial waste. The 2000 series is only of peripheral interest. Some of these categories (2050 Restaurants, 2090 Offices, for example) will generate wastes which can be recorded as characteristic mixtures, as shown on Tables III and IX. Each identifiable material in a waste stream in general will have originated from one or more of the processes listed in Table IV.

From a waste management viewpoint, series 1000, 2000, and 4000 are of interest only insofar as they are generators of waste materials. Series 3000, however, are both generators and receivers of waste materials. Thus for this series, materials of interest will include both process inputs as well as process outputs. These considerations will receive further attention in the chapter dealing with inventory forms for obtaining classifiable waste information.

### Method of Handling, Transportation Mode, Receiving Entity, and Method of Final Disposal

For waste streams as they leave the plant these dimensions (shown in Tables V, VI, VII, and VIII respectively) are self-explanatory classifiers.

### Hazard Attributes

The hazard attributes listed in Table IX may be associated with a waste by virtue of its material composition only. The degree of each type of hazard, however, will depend upon how the material is actually stored, handled, processed, and disposed of, as well as its relative concentration when discharged in a mixture with other materials. A waste stream may of course possess one or more of the indicated hazard attributes.

While the notion of "hazard" provides a most relevant classification dimension, it also introduces a number of problems. For example, perception of hazard associated with a waste stream may vary if industries themselves are requested to make the determination. With the expection of wastes which are radioactive, or toxic to humans, the literature and the state-of-the-art are deficient in providing quantitative threshold criteria that can be uniformly applied to waste classification.

Recognizing these limitations, it is nevertheless useful to classify wastes in this dimension. It will be most applicable to wastes in the 80000 series of Table III, many of which Sax (op. cit.) has classified in this manner. While one may request industry to classify their discharges as to hazard attributes, the results are likely to be more of interest as a test of respondent candor and knowledge regarding the hazards of materials for disposal. Nonetheless, analyses can be performed and data obtained relative to hazardous thresholds independently of an industrial inventory and when the classification system is implemented provision can be made for storing such data.

## Information Content

The 14 items above are proper classifier vectors for a waste information system. Taken together they provide a dimensioned system for categorizing wastes, to which one may append a variety of additional quantitative or qualitative factors. Items 16 through 21 which are discussed in the following section, may be viewed as supplemental classifiers, or as components of an information content vector. In this discussion, it is assumed that they will be additional dimensions, or classifiers within the system.

The information content which can be cross-referenced at random by appropriate classifier specification in "n" dimensions is described below.

### Information About the Plant -

Plant Identification and Location Data;
Plant Resource Consumption (water and various forms of energy);
Economic Data (value added, employees, production volume, etc.);
Transportation Access (rail, barge, etc.);
Number of Waste Streams that Leave the Plant Separately;
Waste Treatment and Handling Processes Employed (type, capacity, costs, etc.);
Secondary and Scrap Materials Utilization (type, quantity, price paid, etc.)

### Information About Each Waste Batch As It Leaves the Plant -

Physical Form;
Quantity as a Batch;
Physical Properties of the Batch (moisture content, density, etc.);
Percentage of Each Material or Chemical Constituent Within Each Batch;
Economic Data for Batch (disposal costs, scrap sales, etc.);

### Materials Information About Each On-Site Waste Treatment Process -

Input Materials (total quantity, and % by material classification and process origin)
Output Materials (total quantity, and % by material classification and process destination);
Value Recovery Data (for each material recovered for in-plant recycling, the estimated value of its use)

Recyclability, disposability, mobility, decomposibility, toxicity, and other "suitability" type indices, are conceptually attractive classifier concepts, but are extremely difficult to implement in any pragmatic manner, except by the classification of related properties. Appropriate classification in all cases requires a specification of the material, of the environment to which the material will be discharged, and a characterization of the dynamic processes within the particular environment (natural or man-made) that tend to disperse or concentrate the material.

One can easily visualize that standard ratings for toxicity, recyclability, disposability, mobility, and decomposability may be developed by defining suitable standard threshold conditions. Only in the case of toxicity, however, have such standards been developed in any depth. Moreover, classification of these attributes would have to be sub-classified by disposal process, and by the receiving environment, so that each material would receive a vector of values for each such "suitability" attributes.

## REFERENCES

## CHAPTER III

1. Environmental Repercussion and the Economic Structure: An Input/Output Approach. Intern. Symp. on Environmental Disruption in the Modern World. March 8-14, 1970, Tokyo, Japan, Inter. Soc. Sci. Council.

# CHAPTER IV. INVENTORY FORMS FOR OBTAINING CLASSIFIED WASTE INFORMATION

## INTRODUCTION

The classification system permits the design of inventory forms following varying approaches. Questions on an inventory form may be oriented toward:

1. Waste material as it leaves the plant;
2. Waste material at the point of generation;
3. Waste input-output accounting for each treatment process.

Those interested in collection and disposal of solid wastes would only be concerned with item #1. For recycling purposes, it would be far preferable to intercept wastes at the point of generation, where they are potentially separable, than as part of a heterogeneous waste stream ready to go out the door. Separation of recyclable materials from a mixed batch is complicated and expensive. In the case of municipal wastes, segregation is difficult to achieve, since it requires the cooperation of thousands of individual householders. In the case of industrial wastes, if there is a good reason to segregate a waste stream or to keep wastes generated in one process separated from wastes generated in another, this can be accomplished quite readily by providing separate collection and storage facilities with severe penalties for disregard of regulations. In other words, the disposition of solid waste in industry, at least the manufacturing industries, can be managed with the same vigilance as the production process itself.

Ideally, a universal classification system should allow a mapping of wastes from the point of generation, through any intermediate steps, to the point of ultimate disposal. Such a map can be constructed by either "backward" or "forward" interrogation.

In the "backward" interrogation process, a respondent first identifies waste streams as they leave the plant and then proceeds to provide information on the origins of each waste stream, tracing materials backward to the points of waste generation.

In the "forward" interrogation process, a respondent first identifies waste at the generating source and then traces materials forward through any treatment process, and finally to the terminal points at which materials exit the plant.

The "forward" scheme aggregates wastes forward to the terminal stream mixtures. The "backward" scheme disaggregates wastes from the terminal mixtures to the points of origin.

## DESIGN OF THE INVENTORY FORMS

Inventory forms for both forward and backward options have been developed and are displayed in Sections A-1 and A-2. In both options the information requested is virtually identical. Also, both have been designed with a view towards a comprehensive identification of all industrial waste streams, whatever their physical form.

Each optional form is divided into three parts. Components of the forms may be deleted if desired, or additional questions of interest may be added later.

In designing the forms the objectives were:

1. To obtain comprehensive data on industrial waste management practice;
2. To achieve an interrogation process that is easy to understand and can be filled out with a minimum of effort;
3. To yield information in a format that can be readily coded for computer processing with a minimum of judgment and effort.

During the course of our work, other inventory forms were tried in preliminary interviews that were conducted. While these were not designed in a manner that took full advantage of the classification system outlined in the previous sections, the experience was invaluable in identifying a number of practical problems encountered by a plant manager in attempting to respond to a series of questions on waste management practices. To the extent possible, Sections B and C were drafted with a view towards minimizing any problems associated with the format of the inventory itself, or any ambiguity in the style of questioning. Our experience in using these forms is discussed in Chapter V, and a number of remaining practical problems to be solved in the actual conduct of a survey are discussed. Further discussion in this chapter is restricted to the logic and rationale of the inventory forms themselves.

### Backward Scheme

### Form PD-I -- Plant Data -

The first two pages request general information about the industrial plant. The plant itself is classified as to its SIC and ZIP codes, and all subsequent information on the inventory form will be referred to these codes. Other information through item 10, pertains to production input factors. The intent here was to permit the subsequent derivation of waste generation functions related to these items. Item 13 (value added) is another useful parameter in this context, but experience has shown that the plant manager, who is likely to fill out the form, is usually unfamiliar with the term. Other plant input data may be added if desired. Questions 11 and 12 clearly pertain to identifying alternative transportation modes that may be available for waste material. Questions 14 through 16 identify the number of separate waste streams that exit the plant while 17 identifies the number of treatment processes employed within the plant. The third page of Part I requests a report on the plant's utilization of secondary or scrap materials.

### Part II -- Terminal Waste Data - (Forms TSB II-A, TLB II-B, TAB II-C, and TGB II-D)

Four separate inventory forms are provided covering solids, liquids not handled in water, aqueous, and gaseous waste streams. For each waste stream that exits the plant, a separate form is filled out. The first group of questions on each form describe attributes of the terminal waste stream as a mixture. The tabular portion of each form requests a listing of the material constituents, and the designation of the origin of each material in the mixture. Specific data related to hazard potential will be filled out by the EPA for each material constituent, using handbook tabulations, field or laboratory analyses.

### Part III -- Waste Treatment - (Form WTP-III)

For each waste treatment process used at the plant, (e.g., incineration, gas cleaning, biological treatment) a separate Part III form is filled out. First the treatment process is identified, and the quantity of material waste input to the process is reported. Then two tables are presented in which each of the materials which enter and leave the process are identified, and their respective origins and destinations are indicated.

## Forward Scheme

### Part I -- Plant Data -

Part I is the same as that shown for the backward scheme.

### Part II -- General Waste Stream Data -

Each waste stream in the plant is identified at its point of origin. This one form accommodates waste streams of all kinds: solid, liquid or gas. When the designated stream has an in-plant destination (i.e., a treatment process) questions 8 through 12 do not apply. When the designated stream is terminal question 7 does not apply. All of the information requested pertains only to the stream as a mixture, and information on material constituents appears in the next part.

Part III -- Material Composition -

For each stream item number identified in Part II, the material composition following the coding of Table III and Table XI is specified.

Comparison of Backward and Forward Options

Either option permits a reconstruction of the waste flow chart. Figure I illustrates a sample industrial waste flow chart. Five terminal streams (boxes in heavy outline) are shown. The backward scheme begins at the terminals and traces materials back to its sources in the plant, going through the treatment processes as required. Thus, in this scheme, each material constituent of a mixture must be identified as to its origin within the plant.

In the forward scheme, any mixture of materials with a common origin and destination automatically receives a separate item identification number. Thus, when reporting the material composition of each mixture, it is not necessary to report the origin of each component as in the backward scheme. Moreover, Part II of the forward scheme automatically contains all pertinent information about the inputs and outputs to each waste treatment process, so that this data does not need to be separately tabulated.

The forward scheme is somewhat more streamlined, but does require a respondent to flow chart the waste streams in advance for orderly response to Part II. The backward scheme isolates discrete components of any industrial waste flow chart (i.e., terminal stream mixtures and treatment processes) and appears to require less organizational effort on the part of the respondent.

Either scheme can be computer coded and processed to yield output information in the identical form.

## SIMPLIFIED WASTE CLASSIFICATION

The inventory forms have been designed to solicit fairly complete data on the generation and disposal of industrial processing wastes. They might be implemented in their entirety or selectively, depending on the objectives of the user. It is important that an Industrial Waste Survey, on the National, State, Regional or local level, only be carried out within the framework of a very carefully defined set of long range objectives. The preparation, distribution, retrieval, and processing of inventory forms is very time consuming, and it is far more efficient to obtain all of the information necessary for meeting a set of objectives in a single solicitation than in a multitude of inquiries. In a recent Regional industrial waste survey, for example, very specific questions were asked about conventional solid wastes (wood, paper, metal, plastic, etc.) and very good data were obtained. Questions on hazardous wastes, flammable and corrosive liquids, and sludges were vague and open-ended, and generated very few responses.

A properly designed inventory form should leave little room for evasive answers. It has been our experience that the Classification Tables in Section A-3 serve both to clarify the detailed level of reporting required, and to bring to mind the full range of wastes actually generated. The data generated can readily be coded for computer storage, as illustrated in Figure II, and it can obviously be retrieved in a variety of forms, some of which are discussed in Chapter V.

For general purpose use, we would recommend a simplified waste classification system based on Table I (Waste Stream Classification), Table V (Material Constituents), and Table XIII (Chemical Classification). The general format would be 00.00000-0000,0000., 00000-0000. 00000-0000, 0000, 0000, etc., when the first two digits represent the waste stream (Table I), and in the following series of digits, the first five code numbers give material constituents and the group of digits following the dash (-) give specific chemical composition. Thus the basic sludge waste generated in the production of chlorine via the diaphragm cell process would be classified as follows:

82. 82003-0227, 0327, 0606.
82002-10

where the digits have the following significance

82 Waste stream - Inorganic sludge containing 50% water or less

82003 Metal Salts

0227 Sodium Chloride

0327 Potassium Chloride

0606 Calcium Carbonate

82002 Metal Bases

10 $Mg(OH)_2$

The waste tars for the production of chlorobenzene by direct chlorination of benzene would be classified as follows:

86.81008 - 00, 09, 10

where the digits have the following significance:

86 Waste stream - solid organics, including tars

81008 Halogenated hydrocarbons

00 Unidentified

09 o-dichlorobenzene

10 p-dichlorobenzene

Figure I: Sample Industrial Waste Flow Chart

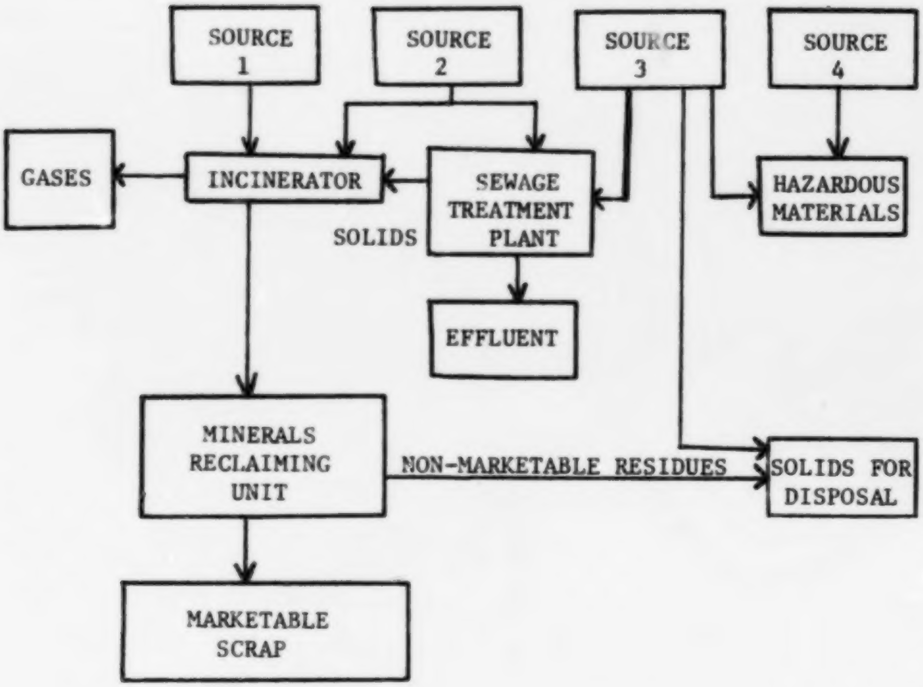
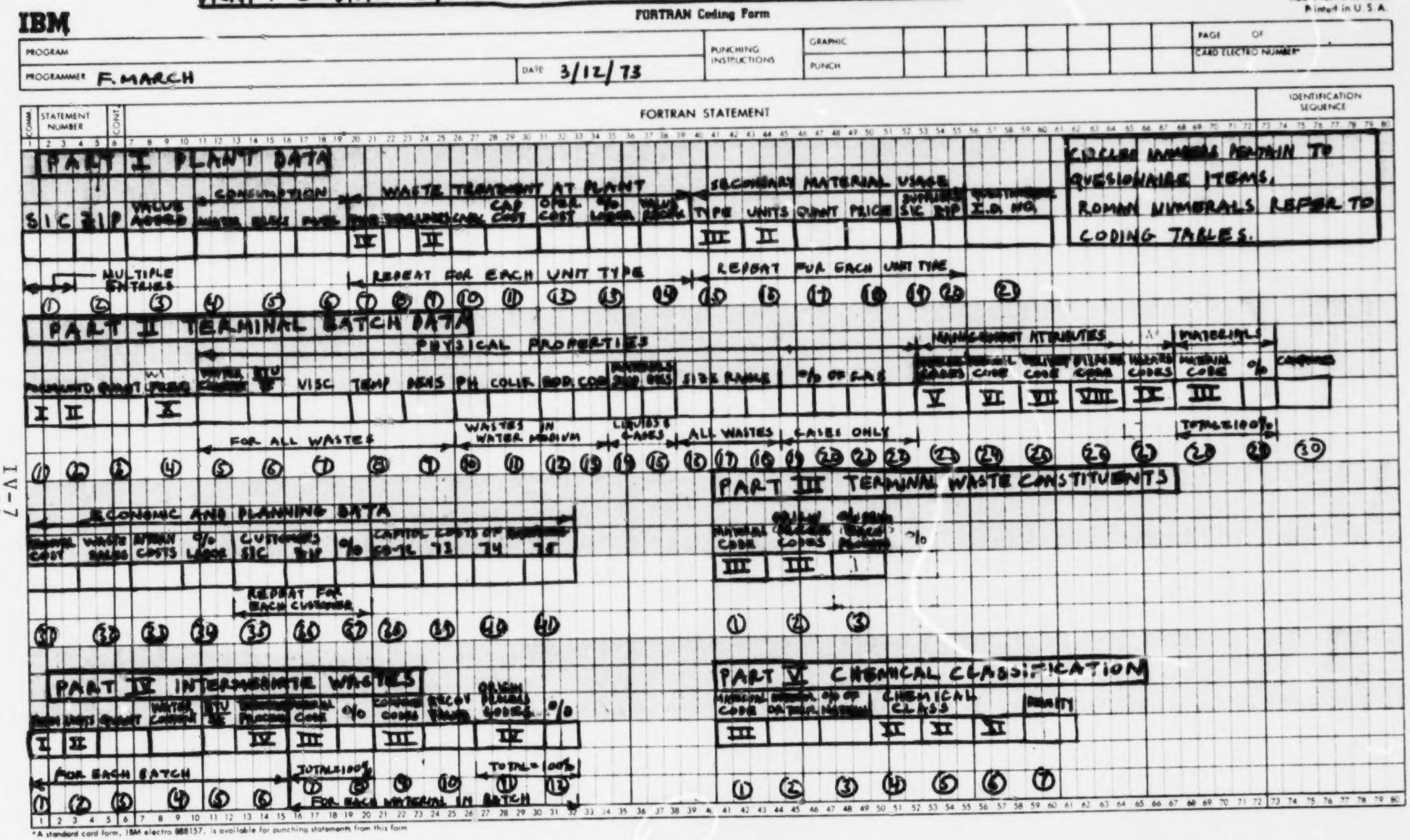

SOURCE 1
SOURCE 2
SOURCE 3
SOURCE 4
GASES
INCINERATOR
SEWAGE TREATMENT PLANT
SOLIDS
HAZARDOUS MATERIALS
EFFLUENT
MINERALS RECLAIMING UNIT
NON-MARKETABLE RESIDUES
SOLIDS FOR DISPOSAL
MARKETABLE SCRAP

FIGURE II

# DRAFT CODING SYSTEM FOR INDUSTRIAL WASTE DATA



IBM FORTRAN Coding Form X28-7327-6 U/M050 Printed in U.S.A.

PROGRAM

PROGRAMMER F. MARCH

DATE 3/12/73

PUNCHING INSTRUCTIONS GRAPHIC PUNCH

PAGE OF

CARD ELECTRO NUMBER*

CIRCLED NUMBERS PERTAIN TO QUESIONAIRE ITEMS, ROMAN NUMERALS REFER TO CODING TABLES.

**PART I PLANT DATA**

SIC | ZIP | VALUE ADDED | CONSUMPTION: WATER, [illegible], FUEL | WASTE TREATMENT AT PLANT: [illegible] IV, [illegible] II, CAP, CAP COST, OPER. COST, % LABOR, [illegible] | SECONDARY MATERIAL USAGE: TYPE III, UNITS II, QUANT, PRICE, SUPPLIER SIC, ZIP | [illegible] I.D. NO.

MULTIPLE ENTRIES — REPEAT FOR EACH UNIT TYPE — REPEAT FOR EACH UNIT TYPE

① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨ ⑩ ⑪ ⑫ ⑬ ⑭ ⑮ ⑯ ⑰ ⑱ ⑲ ⑳ ㉑

**PART II TERMINAL BATCH DATA**

[illegible] I | QUANT II | WT [illegible] X | PHYSICAL PROPERTIES: WATER [illegible], BTU [illegible], VISC, TEMP, DENS, PH, COLIF, BOD, COD, [illegible], SIZE RANGE, % OF [illegible] | MANAGEMENT ATTRIBUTES: [illegible] CODES V, [illegible] CODE VI, DELIVERY CODE VII, DISPOSAL CODE VIII, HAZARD CODES IX | MATERIALS: MATERIAL CODE III, % | [illegible]

FOR ALL WASTES — WASTES IN WATER MEDIUM — LIQUIDS & GASES — ALL WASTES — GASES ONLY — TOTAL=100%

① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨ ⑩ ⑪ ⑫ ⑬ ⑭ ⑮ ⑯ ⑰ ⑱ ⑲ ⑳ ㉑ ㉒ ㉓ ㉔ ㉕ ㉖ ㉗ ㉘ ㉙ ㉚

ECONOMIC AND PLANNING DATA

[illegible] COST | WASTE SALES | [illegible] COSTS | % LABOR | CUSTOMERS SIC, ZIP | % | CAPITAL COSTS OF [illegible]: 69-72, 73, 74, 75

REPEAT FOR EACH CUSTOMER

㉛ ㉜ ㉝ ㉞ ㉟ ㊱ ㊲ ㊳ ㊴ ㊵ ㊶

**PART III TERMINAL WASTE CONSTITUENTS**

MATERIAL CODE III | [illegible] CODES III | [illegible] | %

① ② ③

**PART IV INTERMEDIATE WASTES**

[illegible] I | UNITS II | QUANT | WATER CONTENT | BTU [illegible] | [illegible] IV | MATERIAL CODE III | % | [illegible] CODES III | RECOV [illegible] | ORIGIN [illegible] CODES IV | %

FOR EACH BATCH — TOTAL=100% — TOTAL=100% — FOR EACH MATERIAL IN BATCH

① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨ ⑩ ⑪ ⑫

**PART V CHEMICAL CLASSIFICATION**

MATERIAL CODE III | [illegible] | [illegible] MATERIAL | CHEMICAL CLASS XI, XI, XI | [illegible]

① ② ③ ④ ⑤ ⑥ ⑦

*A standard card form, IBM electro 888157, is available for punching statements from this form

# SECTION A-1

# INDUSTRIAL WASTE INVENTORY FORMS

# (BACKWARD OPTION)

## FORM PD-I, - Plant Data

The following data pertain to the plant, defined as follows:

> A facility, consisting of one or more buildings within a contiguous site, including yard space and all operations within the yard, all of which are integrated to form a single entity. The plant includes all waste treatment processes on site.

21 INVENTORY FORM I.D. CODE __________(EPA will insert)

NAME OF FIRM

NAME OF PLANT

STREET ADDRESS

CITY

STATE

2 ZIP CODE _______

NAME OF PERSON REPORTING

TITLE OF PERSON REPORTING

PHONE NUMBER

DATE OF REPORT

1 SIC (list of all applicable codes) _______

3 NUMBER OF EMPLOYEES _______

4 PRINCIPAL PRODUCTS

| | |
|---|---|
| | Annual Production (state units) |
| ________________ | ________________ |
| ________________ | ________________ |
| ________________ | ________________ |
| ________________ | ________________ |

5 WATER CONSUMPTION (million gallons/year) _______

6 ELECTRIC CONSUMPTION (million kw/year) _______

7 LIQUID FUEL CONSUMPTION (million BTU/year) _______

8 GAS FUEL CONSUMPTION (million BTU/year) _______

9 SOLID FUEL CONSUMPTION (million BTU/year) _______

10 COMMERCIAL STEAM CONSUMPTION (million BTU/year) _______

11 DOES PLANT HAVE A RAIL SIDING? _______

12 DOES PLANT HAVE DIRECT ACCESS TO SHIP OR BARGE _______

13 VALUE ADDED ($ year), IF KNOWN _______

Now, refer to Table I and indicate below the code numbers of all terminal waste streams* that leave your plant and the approximate quantity of material (tons/yr or gallons/yr) in each waste stream. If more than one waste stream is generated within the same classification category, append small letters to the code number (e.g., 87-a, 87-b, 87-c) and add a brief descriptive note characterizing the waste stream.

14 SOLID WASTE STREAM

| Code Number | Quantity | Notes |
|---|---|---|
| | | |
| | | |
| | | |
| | | |
| | | |

15 NON-AQUEOUS LIQUID WASTE STREAMS

| | | |
|---|---|---|
| | | |
| | | |
| | | |
| | | |
| | | |

16 AQUEOUS LIQUID WASTE STREAMS

| | | |
|---|---|---|
| | | |
| | | |
| | | |
| | | |
| | | |

17 GASEOUS WASTE STREAMS

| | | |
|---|---|---|
| | | |
| | | |
| | | |
| | | |
| | | |

*A terminal waste stream is defined as:

> The mixture of waste materials as it leaves the plant (regardless of the origins within the plant) via a specified mode of conveyance directly to the ambient environment, or to a waste receiving entity which will ultimately dispose of the mixture. Thus, the mixture of all materials in a single effluent pipe or smokestack would constitute a single waste stream. Mixtures of solid waste material loaded onto trucks for delivery to a specified waste receiving entity would similarly constitute a single stream.

Next refer to Table II and list below the code numbers of all waste treatment processes used on site and the quantity of waste handled by each (tons/yr or gallons/yr).

| 18 ON SITE WASTE TREATMENT PROCESSES | QUANTITY OF WASTES HANDLED |
|---|---|
| ____________________ | ________________ |
| ____________________ | ________________ |
| ____________________ | ________________ |
| ____________________ | ________________ |
| ____________________ | ________________ |

For each of the waste streams identified in response to Items 14, 15, 16, and 17, fill out one of the following forms:

| For Waste Streams listed under item | Fill out a form |
|---|---|
| 14 | TSB II-A |
| 15 | TLB II-B |
| 16 | TAB II-C |
| 17 | TGB II-D |

For each of the waste treatment processes listed in response to Item 18, fill our a form WTP-III.

## SECONDARY AND SCRAP MATERIALS UTILIZATION

If you use any secondary or scrap materials in your plant, please fill out the Table below.

|  | 25 | 26 | 27 | 28 | 29 | 30 |
|---|---|---|---|---|---|---|
| ITEM | MATERIAL TYPE (Table III) | UNITS (Table II) | QUANTITY | PRICE PAID ($/YEAR) | SUPPLIER SIC | SUPPLIER ZIP |
| 1. |  |  |  |  |  |  |
| 2. |  |  |  |  |  |  |
| 3. |  |  |  |  |  |  |
| 4. |  |  |  |  |  |  |
| 5. |  |  |  |  |  |  |
| 6. |  |  |  |  |  |  |
| 7. |  |  |  |  |  |  |
| 8. |  |  |  |  |  |  |
| 9. |  |  |  |  |  |  |
| 10. |  |  |  |  |  |  |

## FORM TSB II-A

## Terminal Solid Batch Data

## for Solid Wastes as They Leave the Plant

(Fill one form out for each separate solid waste stream listed under Item 14 in Form PD-I)

STREAM IDENTIFICATION (from Form PD-I) ____________

1. QUANTITY (tons/year) ____________
2. FREQUENCY OF TRANSPORT TO DISPOSAL SITE (Table XII) ____________

PROPERTIES OF BATCH

If any property is unknown, indicate your willingness to submit a sample for analysis by W.

3. PHYSICAL FORM (Table III) ____________
4. MOISTURE CONTENT (% of net weight) ____________%
5. WET DENSITY AS LOADED (#/ft$^3$) ____________
6. pH ____________
7. HEAT OF COMBUSTION ____________BTU/lb.
8. % Cl ____________%
9. % ASH ____________%
10. FLASH POINT ____________°F
11. POUR POINT (if response in 3 is 2) ____________°F

MANAGEMENT ATTRIBUTES

12. HANDLING CODES (Table VII-LIST ALL APPLICABLE CODES) ____________
13. TRANSPORTATION CODE (Table VIII) ____________
14. DELIVERY CODE (Table IX) ____________
15. DISPOSAL CODE (Table X) ____________
16. HAZARD CODES (Table XI-LIST ALL APPLICABLE CODES) ____________

MATERIAL CONSTITUENTS

Refer to Table IV, and list below in columns (17) and (18) respectively, the code number and name of each distinct materials component of this waste stream. Refer to Table VI, and list in column (19) the origin process or generating source for each component. In column (20), list the % of each component in the waste stream.

| | | | |
|---|---|---|---|
| 17 | 18 | 19 | 20 |
| MATERIAL CODE (TABLE III) | MATERIAL NAME | ORIGIN PROCESS (TABLE IV) | % of component in the waste stream by dry weight (Put T for trace) |
| ________ | ________ | | % |
| ________ | ________ | | |
| ________ | ________ | | |
| ________ | | | |
| ________ | | | |
| ________ | | | |
| ________ | | | |
| ________ | | | |
| ________ | | | |

Now fill out a form TSB-MC for each of the material constituents listed in column 17, and continue below.

For all material constituents with a first digit code number of 8, and a second digit code number of 1 or 2, refer to Table XIII and fill out the Table below.

| MATERIAL CODE | CHEMICAL CONSTITUENTS (Table XI) | % of MATERIAL AS THE CHEMICAL (Put "T" for trace) |
|---|---|---|
| 81 _ _ _ | | |
| 81 _ _ _ | | |
| 82 _ _ _ | | |
| 82 _ _ _ | | |

ECONOMIC DATA

36. PAYMENT TO OTHERS FOR BATCH REMOVAL ($/Year) ________

37. SALES OF BATCH TO OTHERS ($/Year) ________

38. INTERNAL COSTS OF HANDLING BATCH ($/Year) ________

39. LABOR COSTS AS % OF HANDLING COSTS ________

40. TRANSPORTATION COSTS, IF PAID BY PLANT, TO POINT OF DELIVERY TO RECEIVING ENTITY ($/Year) ________

IF BATCH IS SOLD, COMPLETE THE FOLLOWING TABLE

| CUSTOMERS | 41 CUSTOMER'S SIC | 42 CUSTOMER'S ZIP | 43 % OF SALES TO EACH CUSTOMER |
|---|---|---|---|
| 1. | | | |
| 2. | | | |
| 3. | | | |
| 4. | | | |
| 5. | | | |

FORM TSB-MC

MATERIAL CODE (from column (17), Form TSB III-A) ______________

MATERIAL NAME ______________________________________________

21. Is this constituent of the waste stream drummed or otherwise containerized?

__________yes

__________no

22. If 21. was answered yes, what type of container is used?

______________________________

23. What is the average ratio of long dimension/short dimension for this component?______________________________

24. What is the average volume of a particle or chunk of this material? __________$in^3$ or ________$ft^3$

---

ALL ITEMS BELOW TO BE FILLED OUT BY EPA

| | Yes | No | Unknown |
|---|---|---|---|
| 25. Bioconcentrated | | | |
| 26. Carcenogenic | | | |
| 27. Mutagenic | | | |

28. Flammability, NFPA Category ______________

29. Solubility, ______________ppm

30. Reactivity, NFPA Category ________________

31. Oral toxicity, $LD_{50}$ ______________________mg/kg

32. Dermal penetration, $LD_{50}$, ________________mg/kg

33. Aquatic toxicity, 96 hr. TLM,______________ppm

34. Phytotoxicity, $IL_{50}$, _____________________ppm

35. Irritation, FDA Grade ____________________

# FORM TLB II-B

## Terminal Liquid Batch Data
## For Non-Aqueous Liquid Wastes as They
## Leave the Plant

(Fill one form out for each separate non-aqueous liquid waste stream listed under Item 15 in Form PD-I)

STREAM IDENTIFICATION NO.
(from Form PD-I) ________________

1. QUANTITY (gallons/yr) ________________
2. FREQUENCY OF TRANSPORT TO DISPOSAL SITE (Table XII) ________________

## PROPERTIES OF BATCH

If any property is unknown, indicate your willingness to submit a sample for analysis by W.

3. PHYSICAL FORM (Table III) ________________
4. MOISTURE CONTENT (% of net weight) ________________%
5. DENSITY ________________lbs/ft$^3$
6. pH ________________
7. HEAT OF COMBUSTION ________________BTU/lb
8. % Cl ________________%
9. % ASH ________________%
10. FLASH POINT ________________°F
11. VISCOSITY ________________
12. VAPOR PRESSURE ________________

## MANAGEMENT ATTRIBUTES

13. HANDLING CODES (Table VII-LIST ALL APPLICABLE CODES) ________________
14. TRANSPORTATION CODE (Table VIII) ________________
15. DELIVERY CODE (Table IX) ________________
16. DISPOSAL CODE (Table X) ________________
17. HAZARD CODES (Table XI-LIST ALL APPLICABLE CODES) ________________

## MATERIAL CONSTITUENTS

Refer to Table IV, and list below in columns 18 and 19 respectively, the code number and name of each distinct materials component of this waste stream. Refer to Table VI, and list in column (20) the origin process or generating source for each component.

| 18 | 19 | 20 |
|---|---|---|
| MATERIAL CODE (TABLE III) | MATERIAL NAME | ORIGIN PROCESS (TABLE IV) |
| ______ | ______ | |
| ______ | ______ | |
| ______ | ______ | |
| ______ | | |
| ______ | | |
| ______ | | |
| ______ | | |
| ______ | | |
| ______ | | |

Now fill out a form TSB-MC for each of the material constituents listed in column 18, and continue below.

For all material constituents with a first digit code number of 8, and a second digit code number of 1 or 2, refer to Table XIII and fill out the Table below.

| MATERIAL CODE | CHEMICAL CONSTITUENTS (Table XI) | % of MATERIAL AS THE CHEMICAL (Put "T" for trace) |
|---|---|---|
| 81 _ _ _ | | |
| 81 _ _ _ | | |
| 82 _ _ _ | | |
| 82 _ _ _ | | |

ECONOMIC DATA

36. PAYMENT TO OTHERS FOR BATCH REMOVAL (\$/Year) ______

37. SALES OF BATCH TO OTHERS (\$/Year) ______

38. INTERNAL COSTS OF HANDLING BATCH (\$/Year) ______

39. LABOR COSTS AS % OF HANDLING COSTS ______

40. TRANSPORTATION COSTS, IF PAID BY PLANT, TO POINT OF DELIVERY TO RECEIVING ENTITY (\$/Year) ______

IF BATCH IS SOLD, COMPLETE THE FOLLOWING TABLE

| CUSTOMERS | 41 CUSTOMER'S SIC | 42 CUSTOMER'S ZIP | 43 % OF SALES TO EACH CUSTOMER |
|---|---|---|---|
| 1. | | | |
| 2. | | | |
| 3. | | | |
| 4. | | | |
| 5. | | | |

FORM TSL-MC

MATERIAL CODE (from column ( ); From TSL III-B) ____________________

MATERIAL NAME ________________________________________

22. Is this constituent drummed or otherwise containerized?

_________yes

_________no

23. If 22. was answered yes, what type of container is used?

________________________________________

________________________________________

ALL ITEMS BELOW TO BE FILLED OUT BY EPA

| | Yes | No | Unknown |
|---|---|---|---|
| 24. Bioconcentrated | | | |
| 25. Carcenogenic | | | |
| 26. Mutagenic | | | |

27. Flammability, NFPA Category ____________

28. Solubility, ____________ppm

29. Reactivity, NFPA Category ________________

30. Oral toxicity, $LD_{50}$ ______________________mg/kg

31. Dermal penetration, $LD_{50}$, ________________mg/kg

32. Aquatic toxicity, 96 hr. TLM, ______________ppm

33. Phytotoxicity, $IL_{50}$, ______________________ppm

34. Irritation, FDA Grade ______________________

## FORM TAB II-C

### Terminal Aqueous Stream Data for Aqueous Streams as They Leave the Plant

(Fill one form out for each separate aqueous stream listed under Item 16 in Form PD-I)

*Stream Identification No. (from Form PD-I) ________________

PHYSICAL PROPERTIES OF AQUEOUS STREAMS

1. QUANTITY (MILLION GALLONS/YEAR) ________________
2. TOTAL SOLIDS ($mg/m^3$) ________________
3. TEMPERATURE (IF AMBIENT PUT "X") ________________
4. DENSITY ($\#/ft^3$) ________________
5. pH ________________
6. TOTAL COLIFORMS ________________
7. BOD (5 DAY-$mg/m^3$) ________________
8. COD ($mg/m^3$) ________________
9. SUSPENDED SOLIDS ($mg/m^3$) ________________
10. DISSOLVED MATERIALS ($mg/m^3$) ________________

MANAGEMENT ATTRIBUTES

11. HANDLING CODES (Table VII) ________________
12. REMOVAL CODE (Table VIII) ________________
13. DELIVERY CODE (Table IX) ________________
14. DISPOSAL CODE (Table X) ________________
15. HAZARD CODES (Table XI-LIST ALL APPLICABLE CODES) ________________

MATERIAL CONSTITUENTS

Refer to Table IV, and list below in columns (16) and (17) respectively, the code number and name of each distinct materials component of this waste stream. Refer to Table VI, and list in column (18) the origin process or generating source for each component.

| 16 | 17 | 18 |
|---|---|---|
| MATERIAL CODE (TABLE III) | MATERIAL NAME | ORIGIN PROCESS (TABLE IV) |
| ____________ | ______ | |
| ____________ | ______ | |
| ____________ | ______ | |
| ____________ | | |
| ____________ | | |
| ____________ | | |
| ____________ | | |
| ____________ | | |
| ____________ | | |

Now fill out a form TSB-MC for each of the material constituents listed in column 16, and continue below.

For all material constituents with a first digit code number of 8, and a second digit code number of 1 or 2, refer to Table XIII and fill out the Table below.

| MATERIAL CODE | CHEMICAL CONSTITUENTS (Table XI) | % of MATERIAL AS THE CHEMICAL (Put "T" for trace) |
|---|---|---|
| 81 _ _ _ | | |
| 81 _ _ _ | | |
| 82 _ _ _ | | |
| 82 _ _ _ | | |

ECONOMIC DATA

36. PAYMENT TO OTHERS FOR BATCH REMOVAL ($/Year) ________

37. SALES OF BATCH TO OTHERS ($/Year) ________

38. INTERNAL COSTS OF HANDLING BATCH ($/Year) ________

39. LABOR COSTS AS % OF HANDLING COSTS ________

40. TRANSPORTATION COSTS, IF PAID BY PLANT, TO POINT OF DELIVERY TO RECEIVING ENTITY ($/Year) ________

IF BATCH IS SOLD, COMPLETE THE FOLLOWING TABLE

| CUSTOMERS | 41 CUSTOMER'S SIC | 42 CUSTOMER'S ZIP | 43 % OF SALES TO EACH CUSTOMER |
|---|---|---|---|
| 1. | | | |
| 2. | | | |
| 3. | | | |
| 4. | | | |
| 5. | | | |

## FORM TGB II-D

### Terminal Gas Borne Stream Data for Gaseous and Gas Borne Wastes as They Leave the Plant

(Fill out for each separate batch of gaseous wastes listed under Item 17 in Form PD-I)

*Stream Identification No. (from Form PD-I) ____________________

PHYSICAL PROPERTIES OF GAS STREAM

1. QUANTITY (MILLION CUBIC FEET/YEAR ____________________
2. MOISTURE CONTENT (%) ____________________
3. TEMPERATURE ____________________
4. DENSITY (#ft$^3$ @ 14.7 psi) ____________________
5. PARTICULATE CONCENTRATION (grains/scf) ____________________
6. ORIGIN PROCESS OF THIS GAS STREAM (Table IV) ____________________
7. BTU CONTENT, IF ANY ____________________

MANAGEMENT ATTRIBUTES

8. HANDLING CODES (Table V) ____________________
9. REMOVAL CODE (Table VI) ____________________
10. DELIVERY CODE (Table VII) ____________________
11. DISPOSAL CODE (Table VIII) ____________________
12. HAZARD CODE (Table IX-ALL APPLICABLE HAZARDS) ____________________

MATERIAL CONSTITUENTS

In the attached Table, list in column 12 the concentrations of the various components which are present in the gas stream.

# MATERIAL CONSTITUENTS

| MATERIAL ITEM | MATERIAL NAME | 11<br>MATERIAL CODE<br>(TABLE V) | 12<br>PPM<br>(PUT "T" FOR TRACE) |
|---|---|---|---|
| 1. | $N_2$ | 85001 | |
| 2. | $CO_2$ | 85002 | |
| 3. | CO | 85003 | |
| 4. | SULFUR OXIDES | 85004 | |
| 5. | NITROGEN OXIDES | 85005 | |
| 6. | HYDROGEN SULFIDE | 85006 | |
| 7. | HEAVY METALS (as metals, oxides, or other compounds) | 85009 | |
| 8. | REACTIVE HYDROCARBONS | 85010 | |
| 9. | TOTAL HYDROCARBONS | 85011 | |
| 10. | PARTICULATES | 85012 | |
| 11. | CHEMICALLY CLASSIFIED COMPONENTS | 85013 | |

*Number consecutively for each separate gas stream report.

FORM WTP-III

Waste Treatment

(Fill out a form for each treatment process within the plant identified in Item 18 of Form PD-I)

*PROCESS IDENTIFICATION NO. (from Form PD-I) ____________

NAME OF PROCESS (FROM TABLE IV)

1. FORM OF BATCH (Table III) ____________
2. QUANTITY UNITS (Table IV) ____________
3. QUANTITY OF INPUTS ____________
4. WATER CONTENT (% OF WET WEIGHT) ____________
5. INPUT TREATMENT PROCESS CODE (Table VI) ____________

INPUT MATERIAL CONSTITUENTS

| MATERIAL ITEM | MATERIAL NAME | 6<br>MATERIAL CODE (Table V) | 7<br>% OF BATCH BY DRY WEIGHT | 8<br>PROCESS ORIGIN CODE (Table VI) |
|---|---|---|---|---|
| 1. | | | | |
| 2. | | | | |
| 3. | | | | |
| 4. | | | | |
| 5. | | | | |
| 6. | | | | |
| 7. | | | | |
| 8. | | | | |
| 9. | | | | |
| 10. | | | | |

## OUTPUT MATERIAL CONSTITUENTS

10. TOTAL QUANTITY OF SOLID OR LIQUID OUTPUTS (TONS/YEAR) ______________
OR (MILLION GALLONS/YEAR)

| MATERIAL ITEM | MATERIAL NAME | 11 MATERIAL CODE (Table V) | 12 QUANTITY (% of Total Wet Weight) | 13 WATER CONTENT (%) | 14 PROCESS** DESTINATION CODE (Table IV) | 16 RECOVERY VALUE*** ($/YEAR) |
|---|---|---|---|---|---|---|
| 1. | | | | | | |
| 2. | | | | | | |
| 3. | | | | | | |
| 4. | | | | | | |
| 5. | | | | | | |
| 6. | | | | | | |
| 7. | | | | | | |
| 8. | | | | | | |
| 9. | | | | | | |
| 10. | | | | | | |

* Number consecutively for each process reported, corresponding to listing in Part I.

** Write "T" if material is in terminal form.

*** Includes internal recovery value only. Wastes sold to others have already been reported in Part II.

## ECONOMIC DATA

17. When was this treatment process installed? ________________year

18. What is its annual waste treatment capacity?

______________(gallons/yr, cu ft/yr, T/yr)
(circle appropriate unit)

19. What were the capital costs of installation? $__________________

20. What are the annual operating costs? $______________________/yr

# SECTION A-2

# INDUSTRIAL WASTE INVENTORY FORMS

## (FORWARD OPTION)

## C. INDUSTRIAL WASTE INVENTORY (FORWARD OPTION)

### I. Plant Data (As In Backward Option - Form PD-I)

### II. Waste Generation Processes

The following table is intended to assign stream numbers for coding purposes to waste streams from every segment of the plant operation. The numbering system under here contains four parts: (1) the initial characters S, L, and G, to identify the stream form as solid, liquid, (or slurry), and gas respectively; (2) the letter P to identify a waste generation process (as opposed to I or T for intermediate or terminal waste streams); (3) a number to identify some particular plant process; and (4) the number of the particular stream for the process being considered. For example, the second liquid waste stream from the second process listed in the table has a stream number LP2-2.

| Example: | Plant Area | Process Distribution | Waste Stream # | Stream Description |
|---|---|---|---|---|
| | Steam Plant | Oil boilers 4, 5, 6 | SP1-1 | fly ash & residue |

I. Production Areas

II. Plant Facilities

III. Maintenance

IV. Construction

V. Office

VI. Cafeteria

VII. Other

### III. Waste Treatment Process

Output number code designates either an intermediate stream (I-series) which are inputs for other waste processes, terminal stream (T-series) which either leave the plant without further processing or is disposed of or plant integral recycle stream (R-series) returned to production processes, etc.

| Example: | Treatment Process | Installed (year) | Design Capacity | Investment Cost | Annual Operation Cost | %AOC vs. labor | Input Stream # | Output Stream # |
|---|---|---|---|---|---|---|---|---|
| | Incinerator | 1952 | 100 T/day | $500,000 | $200,000 | 75% | SP1-4 | ST1-1 residue |
| | | | | | | | SP2-1 | ST1-1 stack |
| | | | | | | | | LI1-1 scrubbing water |

I. Mixing/Storage

II. Solid Waste Process

   A. Shredding, etc.
   B. Separation
   C. Bulk Reduction or Conversion

III. Liquid Waste Process

   A. Sewage
   B. Waste Water Treatment
   C. Waste Solvents, Chemical Treatment
   D. Other

IV. Gas Treatment

   A. Particulate Control
   B. Chemical Scrubbing/Treatment
   C. Other

## IV. Stream Data -- Solids

### I. Generation Streams

| # | Description | Quantity | Density as Generated | Chacteristic Particle Dimension | Hazard Code | Handling Code | # Terminal Stream |
|---|---|---|---|---|---|---|---|
| SG1-1 | Boiler Flyash | 42 tons/yr | 50 lbs/ft$^3$ | 25 mesh | 11 | 09 | ST1-1 |

### II. Intermediate Streams

SI1-1
SI1-2

### III. Recycle Streams

### IV. Terminal Streams

IV. Stream Data -- Liquid

I. Generator Stream

| # | Description | Quantity | pH | Coliforms | BOD | COD | SS | DS | Hazard | Handling Code | Terminal # |
|---|---|---|---|---|---|---|---|---|---|---|---|

II. Intermediate

III. Recycle

IV. Terminal

IV. Stream Composition Data (Including all G, I, R, and T series streams)

| # | Code | % wt. | Code | % wt. | Code | % wt. | Code | % wt. | Code | % wt. |
|---|---|---|---|---|---|---|---|---|---|---|
| GS1-1 | 700 | 100 | | | | | | | | |

## IV. Stream Data -- Gases

| # | Description | Quantity | Moisture Content | Particulate (gr/scfd 12% $CO_2$) | $SO_2$ (ppm) | Hydro-Carbon (ppm) | CO (ppm) | $NO_x$ (ppm) | Hazard Code |
|---|---|---|---|---|---|---|---|---|---|

## V. Terminal Stream Supplementary Data

| # | Quantity | Removal Frequency (Table X) | Handling Code | Removal Code | Delivery Code | Disposal Code | Hazard Code | Disposal Cost | Revenues* (See Part VI) |
|---|---|---|---|---|---|---|---|---|---|

VI. Recycle Stream Supplementary Data

1. Plant usage of externally supplied secondary and scrap materials

| Material | Quantity | Value $/yr | Supplies SIC/ZIP |
|---|---|---|---|

II. Internally reused material

| # | Quantity | Value $/yr |
|---|---|---|

III. Terminal Waste Streams, Solid

| # | Total Stream of | Customs SIC/ZIP | Quantity Bought | Value $/yr |
|---|---|---|---|---|

# SECTION A-3

# CLASSIFICATION TABLES FOR INVENTORY FORMS

TABLE I

## WASTE STREAM CLASSIFICATION

### Solid Waste Streams

### Metals

| Code | Description |
|---|---|
| 10 | Obsolete or discarded hardware and equipment |
| 11 | Machine shop waste |
| 12 | Metal dross |
| 13 | Other metal |
| Plastics and Rubbers | |
| 20 | Plastics (other than packaging) and rubber |
| Wood and Paper | |
| 30 | Wood (other than packaging) |
| 31 | Paper (other than packaging) |
| Textiles | |
| 40 | Textiles (non-packaging) |
| Inert Inorganics | |
| 50 | Mining and Mineral Tailings |
| 51 | Fly ash |
| 52 | Slag |
| Biological Product Wastes | |
| 60 | Manure |
| 61 | Dead animals |
| 62 | Animal remains (other than manure) and biological tissue |

| | |
|---|---|
| 63 | Leather |
| 65 | Filter cakes containing natural organic compounds mixed with inorganic solids |
| 66 | Pharmaceutical wastes |
| 70 | Vegetative wastes (shells, stems, leaves, seeds, pulp, straw, etc.) |

### Chemical Wastes

| | |
|---|---|
| 82 | Inorganic solids (other than inerts), filter cakes, wet cakes, and sludges containing 50% water or less |
| 84 | Wet cakes, slurries, and sludges (including sewage or treatment sludge) containing both synthetic organics & inorganics |
| 85 | Other waste streams containing synthetic organic compounds mixed with inorganic solids |
| 86 | Solid organics, including tars |

### Non-aqueous Liquid Waste Streams

| | |
|---|---|
| 87 | Non-aqueous liquid streams containing organics |

### Aqueous Liquid Waste Streams

| | |
|---|---|
| 80 | Aqueous streams containing inorganic compounds in solution |
| 81 | Inorganic aqueous slurries, slimes, and sludges (containing more than 50% water) |
| 83 | Aqueous streams containing both inorganics and organics in solution |
| 88 | Aqueous streams containing synthetic organics, including oils, soaps or detergents |
| 64 | Aqueous streams containing proteins, fats, and/or carbohydrates derived from plant or animal products |

Gaseous Waste Streams

| | |
|---|---|
| 86 | Stack gases |

Common Waste Mixtures (no reporting necessary)

| | |
|---|---|
| 91 | Restaurant and cafeteria wastes |
| 92 | Office wastes |
| 93 | Construction and demolition debris |
| 94 | External maintenance wastes |
| 95 | Packaging wastes |
| 96 | Sanitary sewage and wastewaters |

## TABLE II

## ON-SITE WASTE TREATMENT PROCESSES

| | |
|---|---|
| 3100 | HIGH TEMPERATURE SYSTEMS |
| 3101 | CONTROLLED AIR INCINERATOR |
| 3102 | ROTARY KILN INCINERATOR |
| 3103 | CATALYTIC INCINERATOR |
| 3104 | FLUID BED INCINERATOR |
| 3105 | HIGH TEMPERATURE SLAGGING |
| 3106 | OPEN PIT TEEPEE INCINERATORS |
| 3107 | STOKER FURNACES |
| 3108 | BATCH INCINERATOR |
| 3109 | FUSION TORCH INCINERATOR |
| 3110 | PARTIAL OXIDATION |
| 3111 | PYROLYSIS |
| 3119 | OTHER HIGH TEMPERATURE SYSTEMS |
| 3200 | CONCENTRATED WASTE LIQUID AND SLUDGE SYSTEMS |
| 3201 | CENTRIFUGE |
| 3202 | FILTRATION |
| 3203 | EVAPORATION & CONCENTRATION |
| 3204 | DISTILLATION |
| 3205 | LIQUID-LIQUID EXTRACTION |
| 3206 | BIOLOGICAL SLUDGE & OIL DIGESTION |
| 3219 | OTHER CONCENTRATED WASTE LIQUID SYSTEMS |
| 3300 | DILUTE WASTE WATER SYSTEMS |
| 3301 | SETTLING TANKS (with or without precipitating agents) |
| 3302 | NEUTRALIZATION |
| 3303 | LIQUID-LIQUID SEPARATION (skimmers, gravity separators) |
| 3304 | BIOLOGICAL OXIDATION - LAGOONS |
| 3305 | BIOLOGICAL OXIDATION - TRICKLING FILTERS |
| 3306 | BIOLOGICAL OXIDATION - AERATION |
| 3307 | BIOLOGICAL OXIDATION - ACTIVATED SLUDGE |
| 3308 | ACTIVATE CARBON ADSORPTION |
| 3309 | ION EXCHANGE SYSTEMS |
| 3319 | OTHER DILUTE WASTEWATER SYSTEMS |
| 3400 | WASTE GAS TREATMENT SYSTEMS |
| 3401 | MECHANICAL COLLECTORS |
| 3402 | ELECTROSTATIC PRECIPITATORS |
| 3403 | FABRIC FILTERS |
| 3404 | WET SCRUBBERS |
| 3405 | CONDENSORS |
| 3406 | ACTIVATED CARBON ADORPTION |
| 3407 | OTHER WASTE GAS TREATMENT |

| | |
|---|---|
| 3500 | COMPOSTING SYSTEMS |
| 3501 | WIND RUN COMPOSTING |
| 3502 | MECHANICAL COMPOSTING |
| 3600 | SOLID SEPARATING SYSTEMS |
| 3601 | MAGNETIC SEPARATION |
| 3602 | WET PROCESS MATERIAL SEPARATION SYSTEMS |
| 3603 | DRY PROCESS MATERIAL SEPARATION SYSTEMS |
| 3604 | OPTICAL SORTING SYSTEMS |
| 3605 | MANUAL SEGREGATION OF MATERIAL |

## TABLE III

## PHYSICAL FORM OF BATCH

1. Solid
2. Tar -- Liquid, Not Pourable At Room Temperature; Lower Viscosity At High Temperatures;
3. Slurry -- Pourable Solid-Liquid Mixtures
4. Liquid -- Low Viscosity, Flows in Pipes; Pumpable;
5. Sludge -- Thick, Viscos, Non-Pumpable Mixture of Liquids and Solids;
6. Gas
7. Aerosol

## TABLE IV

## UNITS CODE

1. Tons
2. Million Gallons
3. Million Cubic Feet

(per day when reporting equipment capacity)

(per year when reporting material quantities)

# TABLE V

## WASTE MATERIAL CODES

| | |
|---|---|
| 10000 | METALS |
| 11000 | FERROUS METALS |
| 11100 | LARGELY FERROUS BULK SCRAP |
| 11101 | AUTOMOBILES AND MOTORCYCLES |
| 11102 | TRUCKS |
| 11103 | SHIPS AND BOATS |
| 11104 | AIRPLANES |
| 11105 | LOCOMOTIVES |
| 11106 | ENGINES AND MOTORS |
| 11107 | GENERATORS, PUMPS, TURBINES AND COMPRESSORS |
| 11108 | OTHER WHOLE MACHINERY UNITS |
| 11109 | FREIGHT CARS, TRAILERS, BARGES AND OTHER MOBILE UNITS WITHOUT MACHINERY |
| 11110 | TOOLS, DIES, MACHINE SHOP EQUIPMENT, ETC. |
| 11111 | STORAGE DRUMS |
| 11119 | OTHER LARGE BULK LARGELY FERROUS SCRAP |
| 11200 | UNPLATED FERROUS MATERIALS AND ALLOYS |
| 11211 | IRON -- ALL GRADES |
| 11212 | CARBON STEEL |
| 11213 | STAINLESS STEEL |
| 11214 | TUNGSTEN STEEL |
| 11215 | TITANIUM STEEL |
| 11219 | OTHER STEELS AND FERROUS ALLOYS |
| 11300 | PLATED FERROUS MATERIALS |
| 11301 | CHROME PLATED |
| 11302 | ZINC PLATED |
| 11303 | TIN PLATED |
| 11304 | NICKEL PLATED |
| 11305 | COPPER PLATED |
| 11306 | CADMIUM PLATED |
| 11319 | OTHER PLATED |
| 12000 | NON FERROUS METALS |
| 12100 | INDEPENDENTLY OCCURRING NON FERROUS |
| 12101 | ALUMINUM |
| 12102 | COPPER |
| 12103 | LEAD |
| 12104 | ZINC |
| 12105 | TIN |
| 12106 | NICKEL |

| | |
|---|---|
| 12107 | MERCURY |
| 12108 | SILVER |
| 12109 | CHROMIUM |
| 12110 | MANGANESE |
| 12111 | TITANIUM |
| 12112 | ZIRCONIUM |
| 12113 | GOLD |
| 12114 | PLATINUM |
| 12115 | TUNGSTON |
| 12116 | CADMIUM |
| 12117 | BERYLLIUM |
| 12118 | TELLURIUM |
| 12119 | MAGNESIUM |
| 12120 | MOLYBDENUM |
| 12121 | PALLADIUM |
| 12122 | SELENIUM |
| 12123 | SILICON |
| 12124 | BORON |
| 12125 | BISMUTH |
| 12126 | COBALT |
| 12127 | GERMANIUM |
| 12128 | RADIUM |
| 12129 | URANIUM |
| 12149 | OTHER NON FERROUS |
| 12200 | NON FERROUS ALLOYS |
| 12201 | BRASS |
| 12202 | BRONZE |
| 12203 | CONSTANTAN |
| 12204 | PEWTER |
| 12205 | SOLDER |
| 12206 | BABBITTS |
| 12207 | BISMUTH ALLOY |
| 12208 | MONEL |
| 12219 | OTHER NON FERROUS ALLOYS |
| 12300 | BULK AND COMPOSITE NON FERROUS SOURCES |
| 12301 | LARGELY ALUMINUM MACHINERY AND BODIES |
| 12302 | BATTERIES |
| 12303 | CABLES AND COVERINGS |
| 20000 | RESINS, PLASTICS AND RUBBERS |
| 21000 | THERMOPLASTIC RESINS |
| 21001 | POLYETHYLENE-LOW DENSITY |
| 21002 | POLYETHYLENE-HIGH DENSITY |
| 21003 | POLYVINYL CHLORIDE |
| 21004 | POLYSTYRENE (STRAIGHT & RUBBER MODIFIED) |
| 21005 | POLYPROPYLENE |
| 21006 | CELLULOSICS |
| 21019 | OTHER THERMOPLASTIC RESINS |

### 22000 THERMOSETTING RESINS

| | |
|---|---|
| 22001 | PHENOLIC |
| 22002 | ALKYD |
| 22003 | POLYESTER |
| 22004 | UREA AND MELAMINE |
| 22005 | COUMARONE-INDENE |
| 22006 | EPOXY |
| 22019 | OTHER THEMOSETTING RESINS |

### 23000 LARGELY RUBBER PRODUCTS

| | |
|---|---|
| 23001 | TIRES |
| 23002 | TIRE TUBES |
| 23003 | FOAM AND SPONGE |
| 23004 | SHEET |
| 23005 | HOSE |
| 23006 | MECHANICAL GOODS |
| 23019 | OTHER RUBBER |

## 30000 WOOD AND PAPER MATERIALS

### 31000 WOOD PRODUCTS (NON-PAPER)

| | |
|---|---|
| 31001 | NATURAL WOOD - SCRAPS, ETC. |
| 31002 | BARK |
| 31003 | PULP |
| 31004 | LEAVES, PINE CONES, ETC. |
| 31005 | DRUMS |
| 31006 | PALLETS |
| 31007 | NATURAL WOOD, SAWDUST |
| 31019 | OTHER WOOD PRODUCTS |

### 32000 PAPER PRODUCTS

| | |
|---|---|
| 32001 | PURE PAPERS AND CARDBOARDS, - SCRAPS, CUTTINGS, ETC. |
| 32002 | PRINTED PAPER MATERIALS, BOOKS, MAGAZINES, ETC. |
| 32003 | WALLBOARDS - UNCOATED |
| 32004 | PULPED PAPER |
| 32019 | OTHER PAPER PRODUCTS |

### 33000 COMPOSITE PAPERS, CARBOARDS, AND WALLBOARDS

| | |
|---|---|
| 33001 | WAX COATED |
| 33002 | PLASTIC COATED |
| 33003 | OIL AND ASPHALTIC COATINGS |
| 33004 | ALUMINUM COATED |
| 33005 | CARBON COATED |
| 33006 | PLASTER COATED |
| 33119 | OTHER COATING AND COMPOSITES |

## 40000 TEXTILES AND RELATED FIBRES

### 41000 NATURAL FIBRES

| | |
|---|---|
| 41001 | COTTON |
| 41002 | WOOL |
| 41003 | SILK |
| 41004 | ASBESTOS |
| 41005 | GLASS |
| 41006 | JUTE AND DERIVATIVES - BURLAP, ROPE, ETC. |
| 41007 | FLAX WASTE |
| 41008 | HEMP WASTE |
| 41009 | WORSTED WASTE |
| 41010 | LINTERS |
| 41019 | OTHER NATURAL FIBRES |

### 42000 SYNTHETIC FIBRES

| | |
|---|---|
| 42001 | RAYON |
| 42002 | NYLON |
| 42003 | POLYESTERS - DACRON, FURTREL, CODEL |
| 42004 | POLYACRYLIC - ORLON, ACRYLAN, CRESLAN, MODACRYLIC |
| 42019 | OTHER SYNTHETIC FIBRES AND BLENDS |

### 43000 COMPOSITE NATURAL-SYNTHETIC FIBRES

| | |
|---|---|
| 43001 | LARGELY COTTON |
| 43002 | LARGELY WOOL |
| 43003 | LARGELY RAYON |
| 43004 | LARGELY NYLON |
| 43005 | LARGELY POLYESTERS |
| 43006 | LARGELY POLYACRYLICS |
| 43019 | OTHER NATURAL-SYNTHETIC COMPOSITES |

## 50000 INERT MATERIALS

### 51000 NATURAL GEOLOGIC ORIGIN

| | |
|---|---|
| 51001 | ROCKS, GRAVELS AND MINE TAILINGS |
| 51002 | SANDS |
| 51003 | SILTS AND OTHER SEDIMENTS |
| 51004 | CLAYS |
| 51005 | DIRT |
| 51006 | DIATOMAGEOUS EARTH |
| 51019 | OTHER NATURAL INERTS |

### 52000 MAN MADE INERTS

| | |
|---|---|
| 52100 | GLASS |
| 52101 | CLEAR |
| 52102 | AMBER |
| 52103 | GREEN |
| 52109 | OTHER COLORS |

52200 NON-GLASS, INORGANIC, NON METALLIC MATERIALS
52201 CERAMICS
52202 BRICKS
52203 CONCRETE & CEMENT
52204 ASPHALTS
52205 PLASTER
52206 RUBBLE
52219 OTHER NON-GLASS INERTS

52300 INDUSTRIAL PROCESS INERTS
52301 SLAGS
52302 COMBUSTION RESIDUES - HEAVY ASHES
52303 COMBUSTION RESIDUES - FLY ASH
52319 OTHER INDUSTRIAL PROCESS INERTS

53000 MISCELLANEOUS MIXES: RUBBLE, CONSTRUCTION & DEMOLITION WASTES

60000 ANIMAL PRODUCT WASTES

61000 ANIMAL PROCESSING WASTES

61001 TISSUES, WASTE VISCERA, ETC.
61002 FATS & DERIVATIVES
61003 BONE
61004 SHELL
61005 FEATHERS
61006 HAIR
61007 UNPROCESSED SKINS AND HIDES
61008 PROCESSED SKINS, HIDES AND LEATHERS
61009 WOOL WASTES - LIGNIN
61019 OTHER ANIMAL PROCESSING WASTES

62000 DAIRY WASTES

63000 LIVE ANIMAL WASTES - RAW MANURES

63001 CATTLE AND OTHER ANIMAL MANURES
63002 POULTRY AND OTHER FOWL MANURES

64000 COMPOSTS OF ANIMAL WASTE

64001 FROM CATTLE AND OTHER ANIMAL MANURES
64002 FROM POULTRY AND FOWL MANURES
64003 OTHER ANIMAL PRODUCT COMPOSTS

65000 DEAD ANIMALS

70000 VEGETATIVE PRODUCT WASTES (EXCEPT WOOD)

70100 EDIBLE FRUIT AND VEGETABLE REMAINS - PUTRESCABLES

70101 SHELLS (FROM NUTS, ETC.)
70102 STEMS, LEAVES, ROOTS, PETALS, ETC.

70103 STRAW

70200 COFFEE GRINDS

70300 SPENT GRAINS (E.G., BEVERAGE FERMENTATION)

70400 BAGASSE

70500 SUGARS

70600 VEGETABLE OILS

70700 VEGETABLE COMPOSTS

70900 OTHER VEGETATIVE PRODUCT WASTES

## 80000 CHEMICAL AND BIOCHEMICAL WASTES

### 81000 ORGANIC CHEMICALS (MUST BE CHEMICALLY CLASSIFIED)

81001 ALIPHATIC (FATTY) ACIDS
81002 AROMATIC (BENZENE) ACIDS
81003 RESIN ACIDS
81004 ALCHOHOLS
81005 ALIPHATIC HYDROCARBONS (PETROLEUM DERIVATIVES)
81006 AROMATIC HYDROCARBONS (BENZENE DERIVATIVES)
81007 SULFONATED HYDROCARBONS
81008 HALOGENATED HYDROCARBONS
81009 ALKALOIDS
81010 ALIPHATIC AMINES AND THEIR SALTS
81011 ANILINES
81012 PYRIDINES
81013 PHENOLS
81014 ALDEHYDES
81015 KETONES
81016 ORGANIC SULFUR COMPOUNDS (SULFIDES, MERCAPTANS)
81017 ORGANOMETALLIC COMPOUNDS
81018 CYANIDES
81019 THIOCYANATES
81020 STEROLS
81021 SUGARS AND CELLULOSE
81022 ESTERS

OTHER ORGANIC CHEMICALS - REFER TO 83000 SERIES

### 82000 INORGANIC CHEMICALS (MUST BE CHEMICALLY CLASSIFIED)

82001 MINERAL AND METAL ACIDS
82002 MINERAL AND METAL BASES
82003 METAL SALTS
82004 OXIDES
82005 SULFIDES
82006 CARBON OR GRAPHITE

OTHER INORGANIC CHEMICALS - REFER TO 830000 SERIES

## 83000 OTHER CHEMICAL PROCESS WASTES NOT PREVIOUSLY LISTED (MUST BE CHEMICALLY CLASSIFIED)

| | |
|---|---|
| 83001 | INKS |
| 83002 | DYES |
| 83003 | PAINTS |
| 83004 | ADHESIVES |
| 83005 | PHARMACEUTICAL WASTES |
| 83006 | PETROCHEMICAL WASTES |
| 83007 | METAL TREATMENT WASTES |
| 83008 | SOLVENTS |
| 83009 | AGRICULTURAL CHEMICALS (PESTICIDES, HERBICIDES, FUNGICIDES, ETC.) |
| 83010 | WAXES AND TARS |
| 83011 | FERMENTATION AND CULTURE WASTES |
| 83012 | OILS |
| 83013 | SOAPS AND DETERGENTS |
| 83999 | OTHER ORGANIC OR INORGANIC CHEMICALS |

## 84000 CONVENTIONAL TREATMENT PROCESS SLUDGES

| | |
|---|---|
| 84100 | FROM BIOLOGICAL SEWAGE TREATMENT |
| 84101 | RAW WET SLUDGE |
| 84102 | DIGESTED WET SLUDGE |
| 84103 | DRIED RAW SLUDGE |
| 84104 | DRIED DIGESTED SLUDGE |
| | |
| 84200 | FROM WATER TREATMENT AND CONDITIONING PLANTS (MUST BE CHEMICALLY CLASSIFIED) |
| 84201 | WET SLUDGE |
| 84202 | DRIED SLUDGE |

## 85000 WASTE GASES AND GAS BORNE WASTES

| | |
|---|---|
| 85001 | NITROGEN |
| 85002 | CARBON DIOXIDE |
| 85003 | CARBON MONOXIDE |
| 85004 | SULFUR OXIDES |
| 85005 | NITROGEN OXIDES |
| 85006 | HYDROGEN SULFIDE |
| 85007 | METHANE |
| 85008 | ALDEHYDES |
| 85009 | LEAD |
| 85010 | REACTIVE HYDROCARBONS |
| 85011 | NON-REACTIVE HYDROCARBONS |
| 85012 | PARTICIPANTS - (OR gr/scfd 12% $CO_2$) |
| 85013 | CHEMICALLY CLASSIFIED COMPONENTS |

90000 MISCELLANEOUS COMMON WASTE MIXTURES
(WASTE ORIGIN IMPLIES A CHARACTERISTIC MATERIALS MIXTURE)

- 91000 RESTAURANT, CAFETERIA AND KITCHEN SOLID WASTE MIXES
- 92000 CONVENTIONAL OFFICE SOLID WASTES
- 93000 CONSTRUCTION AND DEMOLITION DEBRIS
- 94000 EXTERNAL MAINTENANCE WASTES
- 95000 PACKAGING WASTES
- 96000 SANITARY SEWAGE AND WASTEWATERS

## TABLE VI

## ORIGIN PROCESSES
## (INCLUDING TREATMENT PROCESSES)

- 1000 OPERATIONS RELATED TO PLANT'S PRODUCT MANAGEMENT
    - 1100 BASIC MATERIAL PROCESSING & PRODUCTION (UNIT OPERATIONS AND CHEMICAL CONVERSIONS) (involves chemical treatmemt of input materials, e.g., extraction, oxidation, precipitation, heat treatment, plating, etc.)
        - 1101 OFF QUALITY PRODUCT
    - 1200 PRODUCT MANUFACTURING (involves shaping, forming, casting, extruding, cutting, binding, welding, sewing, etc.)
    - 1300 PRODUCT ASSEMBLY OR DISASSEMBLY
    - 1400 PRODUCT PACKAGING (AND BOTTLING), AND SHIPPING
- 2000 OPERATIONS RELATED TO PLANT FACILITIES SERVICES
    - 2010 RECEIVING, UNPACKING, AND WAREHOUSING OPERATIONS
    - 2020 PLANT FURNACE, STEAM & BOILER OPERATIONS
    - 2030 PLANT INTAKE-WATER TREATMENT & FILTERING
    - 2040 PLANT LABORATORY
    - 2050 PLANT RESTAURANT OR CAFETERIA
    - 2060 INTERIOR PLANT MAINTENANCE & CLEANING
    - 2070 EXTERIOR YARD MAINTENANCE & CLEANING
    - 2080 GARAGE-VEHICLE MAINTENANCE AND SERVICE AREA
    - 2090 OFFICES
    - 2100 EQUIPMENT REPLACEMENT
    - 2200 EQUIPMENT CLEANING - TANK WASHING, RINSING, ETC.
- 3000 IN PLANT WASTE TREATMENT AND CONVERSION PROCESSES
    - 3100 HIGH TEMPERATURE SYSTEMS
        - 3101 CONTROLLED AIR INCINERATOR
        - 3102 ROTARY KILN INCINERATOR
        - 3103 CATALYTIC INCINERATOR
        - 3104 FLUID BED INCINERATOR
        - 3105 HIGH TEMPERATURE SLAGGING
        - 3106 OPEN PIT & TEEPEE INCINERATORS
        - 3107 STOKER FURNACES
        - 3108 BATCH INCINERATOR
        - 3109 FUSION TORCH INCINERATOR
        - 3110 PARTIAL OXIDATION
        - 3111 PYROLYSIS
        - 3119 OTHER HIGH TEMPERATURE SYSTEMS

## 3200 CONCENTRATED WASTE LIQUID AND SLUDGE SYSTEMS

3201 CENTRIFUGE
3202 FILTRATION
3203 EVAPORATION & CONCENTRATION
3204 DISTILLATION
3205 LIQUID-LIQUID EXTRACTION
3206 BIOLOGICAL SLUDGE & OIL DIGESTION
3219 OTHER CONCENTRATED WASTE LIQUID SYSTEMS

## 3300 DILUTE WASTE WATER SYSTEMS

3301 SETTLING TANKS (with or without precipitating agents)
3302 NEUTRALIZATION
3303 LIQUID-LIQUID SEPARATION (skimmers, gravity separators)
3304 BIOLOGICAL OXIDATION - LAGOONS
3305 BIOLOGICAL OXIDATION - TRICKLING FILTERS
3306 BIOLOGICAL OXIDATION - AERATION
3307 BIOLOGICAL OXIDATION - ACTIVATED SLUDGE
3308 ACTIVATED CARBON ABSORPTION
3309 ION EXCHANGE SYSTEMS
3310 INTERIM STORAGE LAGOON

## 3400 OTHER CHEMICAL TREATMENT

3401 CRYSTALLIZATION
3402 RELEASE OSMOSIS
3403 LEACHING
3404 STRIPPING
3405 ABSORPTION
3406 DIALYSIS
3407 ELECTRO-DIALYSIS
3408 SOLVENT EXTRACTION
3409 ABSORPTION
3419 OTHER LIQUID TREATMENT SYSTEM

## 3500 COMPOSTING SYSTEMS

3501 WINDROW COMPOSTING
3502 MECHANICAL COMPOSTING

## 3600 SOLID SEPARATING SYSTEMS

3601 MAGNETIC SEPARATION
3602 WET PROCESS MATERIAL SEPARATION SYSTEMS
3603 DRY PROCESS MATERIAL SEPARATION SYSTEMS
3604 OPTICAL SORTING SYSTEMS
3605 MANUAL SEGREGATION OF MATERIAL

### 3700 WASTE GAS TREATMENT SYSTEMS

3701 MECHANICAL COLLECTORS
3702 ELECTROSTATIS PRECIPITATORS
3703 FABRIC FILTERS
3704 WET SCRUBBERS
3705 CONDENSORS
3706 ACTIVATED CARBON ABSORPTION
3719 OTHER WASTE GAS TREATMENT

## 4000 NON-MANUFACTURING PLANT WASTE SOURCES

### 4100 CONSTRUCTION

4101 BUILDINGS
4102 OTHER OUTDOOR FACILITIES
4103 ROADS & RAIL
4104 PIPELINE
4105 DAMS & RESERVOIRS
4106 CANALS & DITCHES
4107 DREDGING
4199 OTHER CONSTRUCTION

### 4200 DEMOLITION

4201 BUILDINGS & HOUSES
4202 INDUSTRIAL PLANTS & FACILITIES
4299 OTHER DEMOLITION

### 4300 MINING

4301 STRIP MINING
4302 DEEP MINING

### 4400 AGRICULTURAL

4401 HARVEST & FARM MAINTENANCE OPERATIONS
4402 ANIMAL RANCHING & FEEDING

### 4500 INSTITUTIONAL SOURCES

4501 HOSPITALS & NURSING HOMES
4502 DETENTION & RESIDENT CENTERS (JAILS, ORPHANAGES, ETC.)
4053 SCHOOLS
4504 LIBRARIES
4505 ZOOS
4506 AQUARIA
4507 MUSEUMS

## 4600 MISCELLANEOUS NON-PLANT WASTE SOURCES

| | |
|---|---|
| 4601 | RESTAURANTS, CAFETERIAS AND KITCHENS |
| 4602 | OFFICES & OFFICE BUILDINGS |
| 4603 | SUPERMARKETS, GROCERIES & FOOD RETAIL ESTABLISHMENTS |
| 4604 | OTHER RETAIL OPERATIONS |
| 4605 | HOUSEHOLDS |
| 4606 | MUNICIPAL STREET CLEANING & MAINTENANCE |
| 4607 | PARK & GARDEN MAINTENANCE |

## 5000 STORAGE & TRANSFER FACILITIES

| | |
|---|---|
| 5001 | WASTE PILE |
| 5002 | CONVENTIONAL CANS & DRUMS |
| 5003 | DUMSTER TYPE CONTAINERS |
| 5004 | SEALED CONTAINERS |
| 5005 | TRANSFER STATION |

## TABLE VII

## HANDLING CODES

| | |
|---|---|
| 010 | DEWATERED |
| 020 | PULPED |
| 030 | UNIT SIZE REDUCED (MILLED, SHREDDED, GROUND, PULVERIZED, CHIPPED, ETC.) |
| 040 | SORTED BY MATERIAL (SEGREGATED) |
| 050 | COMPRESSED, CRUSHED, OR COMPACTED |
| 070 | BALED |
| 080 | CONTAINERIZED OR TANKED |
| 081 | HEATED TANK |
| 082 | DRUMMED |
| 083 | BAGGED |
| 084 | ENCAPSULATED |
| 090 | WASHED |
| 0100 | DISINFECTED |
| 0110 | MOVED VIA CONVEYOR ON SITE |
| 0120 | MOVED VIA PIPELINE ON SITE |
| 0130 | MOVED VIA OTHER MECHANISM SUCH AS CLAMSHELL BUCKET |
| 0140 | MANUALLY HANDLED |
| 0150 | EXTRUDED |

## TABLE VIII

## TRANSPORTATION CODES

| | |
|---|---|
| 01 | TRUCK |
| 02 | RAIL |
| 03 | BARGE OR SHIP |
| 04 | AIRPLANE |
| 05 | DIRECT DISCHARGE TO: PUBLIC SEWER |
| 06 | : RIVER |
| 07 | : LAKE OR RESERVOIR |
| 08 | : OCEAN |
| 09 | : GROUND (WELL INJECTION) |
| 10 | AIRBORNE (E.G. VIA STACK) |
| 11 | REMAINS ON SITE |

## TABLE IX

## DELIVERY ENTITY CODES

| | |
|---|---|
| 01 | PUBLIC WASTE AGENCY - MUNICIPAL |
| 02 | " " " - COUNTY |
| 03 | " " " - REGIONAL |
| 04 | " " " - STATE |
| 05 | " " " - INTER-STATE |
| 06 | " " " - NATIONAL |
| 07 | " " " - INTERNATIONAL |
| 08 | INDUSTRIAL OR COOPERATIVE WASTE ASSOCIATION |
| 09 | PRIVATE WASTE DISPOSAL CONTRACTOR |
| 10 | SALVAGE DEALER |
| 11 | OTHER INDUSTRY |
| 12 | SELF DISPOSAL |
| 13 | OTHER |

## TABLE X

## FINAL DISPOSAL CODES

| | | |
|---|---|---|
| 01x | LANDFILL OR DUMP* | - no intermediate treatment |
| 02x | OCEAN DUMP* | |
| 03x | OTHER WATER DUMP | |
| 04x | INCINERATE - THERMAL RECOVERY* | |
| 05x | INCINERATE - NO THERMAL RECOVERY | |
| 06x | PYROLYZE* | |
| 07 | HYDROLYZE | |
| 08 | COMPOST OR DIGEST | |
| 09 | REUSE OR RECYCLE | |
| 10 | TREAT AS SEWAGE: LESS THAN PRIMARY | |
| 11 | TREAT AS SEWAGE: PRIMARY | |
| 12 | TREAT AS SEWAGE: SECONDARY | |
| 13 | TREAT AS SEWAGE: TERTIARY | |
| 14 | OTHER TREATMENT PROCESS | |
| 15 | DEEP WELL INJECTION | |
| 16 | DEEP MINE DISPOSAL | |
| 17 | IRRIGATION OR SOIL ENRICHMENT | |
| 18 | OTHER DISPOSAL METHOD | |

*If facility is public, set x = 0
If facility is private, set x = 1

# TABLE XI

## HAZARD CODES

(IF IMPROPERLY HANDLED, STORED OR DISPOSED)

| | | |
|---|---|---|
| 01 | | EXPLOSIVE |
| 02 | | RADIOACTIVE |
| | 021 | PENETRATING |
| | 022 | NON-PENETRATING |
| 03 | | PATHOGENIC |
| 04 | | CARCINOGENIC - Very difficult to determine |
| 05 | | MUTAGENIC |
| 06 | | TERATOGENIC - Very difficult to determine |
| 07 | | CORROSIVE |
| 08 | | FLAMMABLE |
| 09 | | TOXIC TO HUMANS UPON : INHALATION |
| 10 | | : INGESTION |
| 11 | | : CONTACT |
| 12 | | DESTRUCTIVE OF PLANT OR ANIMAL LIFE IN THE ENVIRONMENT |
| 13 | | OTHERWISE ENVIRONMENTALLY DANGEROUS IF IMPROPERLY HANDLED OR DISPOSED |

## TABLE XII

## BATCH FREQUENCY CODE

| | |
|---|---|
| 01 | CONTINUOUS 24 HOUR DISCHARGE |
| 02 | 7 DAYS PER WEEK |
| 03 | 5 DAYS PER WEEK |
| 04 | 2-4 DAYS PER WEEK |
| 05 | 1 DAY PER WEEK |
| 06 | 2-3 TIMES PER MONTH |
| 07 | 1 TIME PER MONTH (8-12 TIMES PER YEAR) |
| 08 | 3-7 TIMES PER YEAR |
| 09 | 2 TIMES PER YEAR |
| 10 | ONCE ANNUALLY |
| 12 | EVERY SECOND YEAR |
| 13 | EVERY THIRD YEAR |
| 1n | EVERY nth YEAR |
| 19 | EVERY NINTH YEAR |
| 20 | EVERY TENTH YEAR |
| 21 | EVERY ELEVENTH YEAR |
| 2n | EVERY (10+ n) YEARS |
| 29 | EVERY NINETEENTH YEAR |
| mn | EVERY ( (m-1)x 10 + n) YEARS |

# TABLE XIII

## CHEMICAL CLASSIFICATION

### INORGANIC CHEMICAL CLASSIFICATION (82000)

### 82001 MINERAL AND METAL ACIDS

82001 - 01 $H_2SO_4$
- 02 $HClSO_3$
- 03 Arsenic acid
- 04 $HCl$
- 05 $HNO_3$
- 06 $H_3PO_4$
- 07 $H_2S$
- 08 $HF$
- 09 $HBF_4$
- 10 $H_3PO_3$

### 82002 MINERAL AND METAL BASES

82002 - 01 $KOH$
- 02 $NaOH$
- 03 $Ca(OH)_2$
- 04 $Fe(OH)_2$
- 05 $Cd(OH)_2$
- 06 $NH_4OH$
- 07 $Cu(OH)_2$
- 08 $Ni(OH)_2$
- 09 $Cr(OH)_3$
- 10 $Mg(OH)_2$

## 82003 METAL SALTS

82003 - xy - vw

| xy | Cation Constituents |
|---|---|
| 01 | Li |
| 02 | Na |
| 03 | K |
| 04 | Be |
| 05 | Mg |
| 06 | Ca |
| 07 | Sr |
| 08 | Ba |
| 09 | Ti |
| 10 | Zr |
| 11 | Hf |
| 12 | V |
| 13 | Nb |
| 14 | Ta |
| 15 | Cr |
| 16 | Mo |
| 17 | W |
| 18 | Mn |
| 19 | Fe |
| 20 | Co |
| 21 | Ni |
| 22 | Cu |
| 23 | Ag |
| 24 | Au |
| 25 | Zn |
| 26 | Cd |
| 27 | Hg |
| 28 | B |
| 29 | Al |
| 30 | Si |
| 31 | Ge |
| 32 | Sn |

| xy | Cation Constituents |
|---|---|
| 33 | Pb |
| 34 | P |
| 35 | As |
| 36 | Sb |
| 37 | Bi |
| 38 | S |
| 39 | Pt |
| 40 | Rare earths |
| 41 | $NH_4$ |

| vw | Anion Constituent |
|---|---|
| 01 | Hydrides |
| 02 | Thiocarbamates |
| 03 | Borides |
| 04 | Borates |
| 05 | Carbides |
| 06 | Carbonates and bicarbonates |
| 07 | Nitrides |
| 08 | Azides |
| 09 | Cyanides |
| 10 | Thiocyanates |
| 11 | Ferro(i)cyanides |
| 12 | Amides |
| 13 | Nitrites |
| 14 | Nitrates |
| 18 | Sulfites and bisulfites |
| 19 | Sulfates and bisulfates |
| 20 | Fluorides |
| 21 | Fluorine oxy-anions |
| 22 | Aluminates |
| 23 | Silicides |
| 24 | Silicates |
| 25 | Phosphides |
| 26 | Phosphates (all) |
| 27 | Chlorides |
| 28 | Chlorine oxy-anions |
| 29 | Titanate |
| 30 | Vanadate |
| 31 | Chromium oxy-anions |
| 32 | Manganese oxy-anions |
| 33 | Zincates |

| vw Anion | Constituent |
|---|---|
| 34 | Arsenides |
| 35 | Arsenic oxy-anions |
| 36 | Selenides or tellurides |
| 37 | Selenium or tellurium oxy-anions |
| 38 | Bromide or iodide |
| 39 | Bromine and iodine oxy-anions |
| 40-92 | For other metal oxy-anions for at. no. ≥ 40 use at no. of metal; for example 74 = tungstate |
| 93 | Metal halo-anions |
| 94 | Miscellaneous |

## ORGANIC CHEMICAL CLASSIFICATION (81000)

### 81001 ALIPHATIC ACIDS

| | |
|---|---|
| 81001 - 01 | Acetic acid |
| - 02 | Acetic anhydride |
| - 03 | Acrylic acid |
| - 04 | Adipic acid |
| - 05 | Formic acid |
| - 06 | Maleic anhydride |
| - 07 | Oleic Acid |
| - 08 | Oxalic acid |
| - 09 | Propionic acid |
| - 99 | Other (specify) |

### 81002 AROMATIC ACIDS

| | |
|---|---|
| 81002 - 01 | Benzoic acid |
| - 02 | Phthalic anhydride |
| - 03 | Salicylic acid |
| - 99 | Other (specify) |

## 81004 ALCOHOLS

| | |
|---|---|
| 81004 - 01 | Allyl alcohol |
| - 02 | Amyl alcohol |
| - 03 | 1,4 Butanediol |
| - 04 | 1,2,4-Butanetriol trinitrate |
| - 05 | 1,4 Butenediol |
| - 06 | n- Butyl alcohol |
| - 07 | sec- Butyl alcohol |
| - 08 | tert- butyl alcohol |
| - 09 | 1,4 Butynediol |
| - 10 | Cyclohexanol |
| - 11 | n- decyl alcohol |
| - 12 | diacetone alcohol |
| - 13 | diethylene gycol |
| - 14 | diisobutyl carbinol |
| - 15 | dinitrobenzol |
| - 16 | dipropylene glycol |
| - 17 | Dodecanol |
| - 18 | Ethanol |
| - 19 | Ethoxytriglycol |
| - 20 | Ethoxylated dodecanol |
| - 21 | Ethoxylated pentadecanol |
| - 22 | Ethoxylated tetradecanol |
| - 23 | Ethoxylated tridecanol |
| - 24 | Ethylene glycol |
| - 25 | 2- ethyl hexanol |

| | |
|---|---|
| - 26 | Glycerin |
| - 27 | Heptanol |
| - 28 | Hexanol |
| - 29 | Hexylene glycol |
| - 30 | Isoamyl alcohol |
| - 31 | Isobutyl alcohol |
| - 32 | Isodecyl alcohol |
| - 33 | Isooctyl alcohol |
| - 34 | Isopropanol |
| - 35 | Methanol |
| - 36 | Methyl amyl alcohol |
| - 37 | Methyl isobutyl carbinol |
| - 38 | Monanol |
| - 39 | Octanol |
| - 40 | pentadecanol |
| - 41 | n- propyl alcohol |
| - 42 | propylene glycol |
| - 43 | tetradecanol |
| - 44 | tridecanol |
| - 45 | triethylene glycol |
| - 46 | undecanol |
| - 47 | xyleneol |
| - 48 | polyvinyl alcohol |
| - 99 | Other (specify) |

## 81005 ALIPHATIC HYDROCARBONS

| | |
|---|---|
| 81005 - 01 | Acetylene |
| - 02 | Butadiene |
| - 03 | Butane |
| - 04 | 1-Butene |
| - 05 | Butylene |
| - 06 | Cyclohexane |
| - 07 | 1-Decene |
| - 08 | Dicyclopentadiene |
| - 09 | Diisobutylene |
| - 10 | Dioxane |
| - 11 | Dodecene |
| - 12 | Ethane |
| - 13 | Ethylene |
| - 14 | n- heptane |
| - 15 | 1- heptene |
| - 16 | hexane |
| - 17 | 1- hexene |
| - 18 | Isobutane |
| - 19 | Isobutylene |
| - 20 | Isohexane |
| - 21 | Isopentane |
| - 22 | Isoprene |
| - 23 | Methane |
| - 24 | Nitroethane |
| - 25 | Nitromethane |
| - 26 | Nitropropane |

| | |
|---|---|
| - 27 | Nonene |
| - 28 | 1- nonene |
| - 29 | 1- octene |
| - 30 | n- pentane |
| - 31 | 1- pentene |
| - 32 | polybutene |
| - 33 | propane |
| - 34 | propylene |
| - 35 | 1- tetradecene |
| - 36 | 1- tridecene |
| - 37 | 1- undecene |
| - 99 | Other (specify) |

81006 AROMATIC HYDROCARBONS

| | |
|---|---|
| 81006 - 01 | Anthracene |
| - 02 | Benzene |
| - 03 | Diethylbenzene |
| - 04 | Dinitrotoluene |
| - 05 | Dodecyl benzene |
| - 06 | Ethyl benzene |
| - 07 | Napthalene |
| - 08 | Nitrobenzene |
| - 09 | 4- nitrotoluene |
| - 10 | tetrahydronaphthalene |
| - 11 | toluene |
| - 12 | triethyl benzene |
| - 13 | o- xylene |

| | |
|---|---|
| - 14 | m- xylene |
| - 15 | p xylene |
| - 99 | Other (specify) |

81007 SULFONATED HYDROCARBONS

| | |
|---|---|
| 81007 - 01 | Benzene sulfuric acid |
| - 02 | Dimethyl sulfate |
| - 03 | Dimethyl sulfoxide |
| - 99 | Other (specify) |

81008 HALOGENATED HYDROCARBONS

| | |
|---|---|
| 81008 - 01 | Acetyl chloride |
| - 02 | Allyl chloride |
| - 03 | Benzene hexachloride |
| - 04 | Benzoyl chloride |
| - 05 | Benzyl chloride |
| - 06 | Carbon tetrachloride |
| - 07 | Chlorobenzene |
| - 08 | Chloroform |
| - 09 | o- Dichlorobenzene |
| - 10 | p- Dichlorobenzene |
| - 11 | dichlorodifluoromethane |
| - 12 | dichloroethyl ether |
| - 13 | dichloromethane |
| - 14 | 2,4- Dichlorophenol |
| - 15 | Dichlorophenoxyacetic acid |
| - 16 | 1,2- Dichloropropane |
| - 17 | 1,3- Dichloropropene |

| | |
|---|---|
| - 18 | Dichlorotetrafluoroethane |
| - 19 | Ethyl chloride |
| - 20 | Ethylene bromide |
| - 21 | Ethylene dibromide |
| - 22 | Ethylene dichloride |
| - 23 | Heptachlor |
| - 24 | Hexachlorophene |
| - 25 | Methyl bromide |
| - 26 | Methyl chloride |
| - 27 | Methyl chloroformate |
| - 28 | Monochlorodifluoromethane |
| - 29 | Nitrochlorobenzene |
| - 30 | Pentachlorophenol |
| - 31 | Perchloroethylene |
| - 32 | Polychlorinated biphenyls |
| - 33 | Tetrachloroethane |
| - 34 | Trichlorobenzene |
| - 35 | Trichloroethane |
| - 36 | Trichloroethylene |
| - 37 | Trichlorofluoromethane |
| - 38 | Trichlorophenol |
| - 39 | Vinyl chloride |
| - 40 | Vinylidene chloride |
| - 99 | Other (specify) |

## 81010 ALIPHATIC AMINES AND THEIR SALTS

| | | |
|---|---|---|
| 81010 | - 01 | Aminoethanolamine |
| | - 02 | Cyclohexyl amine |
| | - 03 | Diethanol amine |
| | - 04 | Diethyl amine |
| | - 05 | Diethylenetriamine |
| | - 06 | Diisopropanol amine |
| | - 07 | Dimethyl amine |
| | - 08 | Dimethyl formamide |
| | - 09 | 1,1-dimethyl hydrazine |
| | - 10 | Diphenylamine |
| | - 11 | Ethanol amine |
| | - 12 | Ethyl amine |
| | - 13 | Ethyl butanol |
| | - 14 | Ethylene diamine |
| | - 15 | Ethyleneamine |
| | - 16 | Hexamethylenediamine |
| | - 17 | Hexaethylenetetramine |
| | - 18 | Hydrazine |
| | - 19 | Isopropyl amine |
| | - 20 | Methyl amine |
| | - 21 | Monoethanolamine |
| | - 22 | Monoisopropanol amine |
| | - 23 | Propyl amine |
| | - 24 | Triethanol amine |

| | | |
|---|---|---|
| | - 25 | Triethyl amine |
| | - 26 | Triethylenetetramine |
| | - 27 | Trimethyl amine |
| | - 99 | Other (specify) |
| 81011 | ANILINES | |
| 81011 | - 01 | Aniline |
| | - 02 | 2,4- dinitroaniline |
| | - 03 | n- methyl aniline |
| | - 04 | nitroaniline |
| | - 99 | Other (specify) |
| 81012 | PYRIDINES | |
| 81012 | - 01 | Acridine |
| | - 02 | Methyl ethyl pyridine |
| | - 03 | Pyridine |
| | - 99 | Other (specify) |
| 81013 | PHENOLS | |
| 81013 | - 01 | Bisphenol A |
| | - 02 | Butyl phenol |
| | - 03 | Creosol |
| | - 04 | Diazonitrophenol |
| | - 05 | Dinitrophenol |
| | - 06 | Dinitrocresols |
| | - 07 | Ethyl phenol |
| | - 08 | 4- nitrophenol |

| | | |
|---|---|---|
| | - 09 | nonylphenol |
| | - 10 | phenol |
| | - 11 | picric acid |
| | - 99 | Other (specify) |

**81014 ALDEHYDES**

| | | |
|---|---|---|
| 81014 | - 01 | Acetaldehyde |
| | - 02 | Benzaldehyde |
| | - 03 | n- Butyraldhyde |
| | - 04 | iso- Butyraldehyde |
| | - 05 | Crotonaldehyde |
| | - 06 | Decaldehyde |
| | - 07 | Formaldehyde |
| | - 08 | Furfural |
| | - 09 | Isooctylaldehyde |
| | - 10 | Paraformaldehyde |
| | - 11 | Propionaldehyde |
| | - 12 | Valeraldehyde |
| | - 99 | Other (specify) |

**81015 KETONES**

| | | |
|---|---|---|
| 81015 | -01 | Acetone |
| | - 02 | Acetophenone |

|  |  |  |
|---|---|---|
|  | - 03 | Cyclohexanone |
|  | - 04 | Diisobutyl ketone |
|  | - 05 | Ethyl methyl ketone |
|  | - 06 | Hydroquinone |
|  | - 07 | Methyl ethyl ketone |
|  | - 08 | Methyl isobutyl ketone |
|  | - 09 | Quinone |
|  | - 99 | Other (specify) |
| 81016 | ORGANIC SULFUR COMPOUNDS |  |
| 81016 | - 01 | Butyl mercaptan |
|  | - 02 | Carbon disulfide |
|  | - 03 | Ethyl mercaptan |
|  | - 04 | Lauryl mercaptan |
|  | - 05 | Methyl mercaptan |
|  | - 99 | Other (specify) |
| 81017 | ORGANOMETALLIC COMPOUNDS |  |
| 81017 | - 01 | Lead acetate |
|  | - 02 | Lead 2,4- dinitroresorcinate |
|  | - 03 | Lead Styphnote |
|  | - 04 | Lead tetraethyl |
|  | - 05 | Lead tetramethyl |
|  | - 06 | Manganese methylcyclopentadieryltic carbonyl |
|  | - 07 | Potassium binoxalate |
|  | - 08 | Potassium dinitrobenzfuran |

|  |  |  |
|---|---|---|
|  | - 09 | Potassium oxalate |
|  | - 10 | Silver Styphnote |
|  | - 11 | Silver tetrazene |
|  | - 12 | Sodium alkylbenzensulfonate |
|  | - 13 | Sodium alkyl sulfates |
|  | - 14 | Sodium Cacodylate |
|  | - 15 | Sodium oxalate |
|  | - 16 | Aluminum alkyl |
|  | - 99 | Other (specify) |

## 81018 CYANIDES

|  |  |  |
|---|---|---|
| 81018 | - 01 | Acetonitrile |
|  | - 02 | Acrylonitrile |
|  | - 03 | Adiponitrile |
|  | - 99 | Other (specify) |

## 81020 STEROLS

|  |  |  |
|---|---|---|
| 81020 | - 01 | Diethyl stilbesterol |
|  | - 99 | Other (specify) |

## 81021 SUGARS AND CELLULOSE

|  |  |  |
|---|---|---|
| 81021 | - 01 | Dextrose |
|  | - 02 | Carboxyonethyl allulose |
|  | - 99 | Other (specify) |

## 81022 ESTERS

|  |  |  |
|---|---|---|
| 81022 | - 01 | Amyl acetate |
|  | - 02 | n- Butyl acetate |
|  | - 03 | sec- Butyl acetate |

| | | |
|---|---|---|
| | - 04 | n- Butyl acrylate |
| | - 05 | iso- Butyl acrylate |
| | - 06 | Dibutyl phthalate |
| | - 07 | dioctyl adipate |
| | - 08 | Dioctyl phthalate |
| | - 09 | Ethyl acetate |
| | - 10 | Ethyl acrylate |
| | - 11 | Ethyl pthalate |
| | - 12 | Glycidyl methacrylate |
| | - 13 | Isobutyl acetate |
| | - 14 | Isopropyl acetate |
| | - 15 | Methyl acetate |
| | - 16 | Methyl acrylate |
| | - 17 | Methyl amyl acetate |
| | - 18 | Methyl formate |
| | - 19 | Methyl methacrylate |
| | - 20 | n-propyl acetate |
| | - 21 | Vinyl acetate |
| | - 99 | Other (specify) |

### 83009 AGRICULTURAL CHEMICALS

| | | |
|---|---|---|
| 83009 | - 01 | Arsenates |
| | - 02 | Aldrin |
| | - 03 | Chlordane |
| | - 04 | DDD |

| | |
|---|---|
| - 05 | DDT |
| - 06 | Dieldrin |
| - 07 | Endrin |
| - 08 | Grithion |
| - 09 | Malthion |
| - 10 | Methyl parathion |
| - 11 | Parathion |
| - 99 | Other (specify) |

# CHAPTER V. THE NATURE OF INDUSTRIAL SOLID WASTES - A LITERATURE REVIEW

## INTRODUCTION

In both developing the Classification System described in Chapter III, and in testing its applicability to a wide range of industrial wastes and industrial waste management practices, we made extensive use of published data relating to:

a. the waste generating processes within the industry,
b. the specific wastes generated,
c. the quantities of waste produced in various categories,
d. the handling procedures for solid wastes - storage, transport, and disposal,
e. salvage, reuse, recycling, and reclamation practice and potential,
f. environmental impact of industrial solid waste management practice, and
g. the effect of geographical location of specific industries on waste management practice.

The industrial waste management data are most conveniently discussed with reference to the Standard Industrial Classification (SIC) which provides a means for grouping and coding all of the economic activities of the nation. On the basis of the SIC system, the Department of Commerce publishes a great deal of statistical data on industrial production, sales, employment, value added, and number of plants, on both a national and geographic basis. These data are often conveniently correlated with waste management information for the same industries, and can be of invaluable aid in the development of waste multipliers.

In this chapter, we discuss some of the data on waste generation and management, which is available in the literature for particular industries, with an emphasis on processing wastes. In Chapter VII, we present the results of site visits to a number of industrial plants, we have tried to cover a wide range of manufacturing and non-manufacturing industries, as summarized in Table 1 , with a view towards assessing the ability of the Classification System to accommodate the diversity of industrial wastes, and to code the kinds of information needed by individuals and groups concerned with many different aspects of solid waste management. The data on industrial solid processing wastes,

| | | | Literature Review | Site Visit |
|---|---|---|---|---|
| Div. A | Agriculture | | | |
| | 0131 | (cotton) | X | X |
| | 0161 | (vegetable) | X | |
| | 0174 | (citrus) | X | |
| | 0211 | (beef feed lots) | X | X |
| | 0241 | (dairy farms) | X | X |
| | 0252 | (eggs) | X | |
| Div. B | Mining | | | |
| | 1011 | (iron) | X | |
| | 1021 | (copper) | X | |
| | 1111 | (authracite coal) | X | |
| | 1211 | (bituminous coal) | X | |
| | 1475 | (phosphate rock) | X | |
| Div. C | Construction | | | |
| | 1521 | (single family homes) | X | |
| | 1542 | (office buildings) | X | |
| | 1611 | (highway construction) | X | |
| Div. D | Manufacturing | | | |
| | 2011 | (meat packing) | X | X |
| | 2033 | (canned foods) | X | |
| | 2041 | (dairy) | | X |
| | 2044 | (rice milling) | | X |
| | 2051 | (bakery) | X | |
| | 2061 | (sugar) | X | |
| | 2085 | (distillery) | X | |
| | 2091 | (processed fish) | X | |
| | 2095 | (roasted coffee) | X | |
| | 2111 | (cigarettes) | X | |
| | 22 | (cotton, synthetic fabrics) | X | X |
| | 2295 | (resin impregnation) | | X |
| | 23 | (apparel) | X | X |
| | 2361 | (linerboard) | | X |
| | 2421 | (sawmills) | X | |
| | 25 | (furniture & fixtures) | X | |
| | 26 | (paper pulp mills) | X | |
| | 2711 | (newspapers) | X | |
| | 2812 | (chlorine) | X | |
| | 2813 | (gases) | X | |
| | 2816 | (inorganic pigments) | X | |
| | 2819 | (misc. inorganics) | X | |
| | 2821 | (plastic) | X | X |
| | 283 | (drugs) | X | X |
| | 285 | (paint) | | X |
| | 286 | (organic chemicals) | X | X |
| | 287 | (agricultural chemicals) | X | |
| | 2911 | (petroleum refining) | X | X |
| | 3011 | (tires) | X | |
| | 3079 | (plastics) | | X |
| | 3111 | (tanning) | X | X |
| | 3144 | (women's shoes) | X | |
| | 3211 | (glass) | X | |

|  |  |  | Literature Review | Site Visit |
|---|---|---|---|---|
|  | 3232 | (fiberglass mfg.) |  | X |
|  | 3312 | (steel works) | X |  |
|  | 3334 | (aluminum refining) |  | X |
|  | 3519 | (int. combust. engine) |  | X |
|  | 3523 | (tractor plant) | X |  |
|  | 3674 | (semi-conductors) |  | X |
|  | 3679 | (printer circuits) |  | X |
|  | 3691 | (battery mfg.) |  | X |
|  | 3711 | (motor vehicles) |  | X |
|  | 3825 | (electronics & electro-plating |  | X |
| Div. E | Communication & Transportation |  |  |  |
|  | 3861 | (photographic film & cameras) |  | X |
|  | 4953 | (waste disposal) |  | X |
| Div. I | Services |  |  |  |
|  | 7329 | (management consulting) |  | X |
|  | 7399 | (solvents recovery) |  | X |
|  | 8062 | (hospital) |  | X |
|  | 8911 | (chemical construction) |  | X |

including liquids which cannot legitimately be handled in an aqueous effluent, are quite sparse. Most industries, faced with the necessity of complying with established water quality criteria, have analyzed their aqueous process streams in considerable detail. There is also a good deal of material published on waste water treatment facilities appropriate to the different industries, and on the degree to which treatment is effective in removing pollutants from streams ultimately discharged to receiving waters. However, almost all such treatment facilities produce a sludge which must be handled as solid waste, and although many of the contaminants removed from the aqueous stream may be contained in these sludges, they are normally not characterized in any detail with respect to their suitability for landfill or incineration.

Many of the studies addressed specifically to industrial solid wastes interpret the term "solid" too literally. In some cases, fairly extensive waste surveys were carried out within selected industrial sectors and data were obtained only on those process wastes which are physically solids. Thus, while excellent data are available on aqueous processing streams, and fair data are available on solid waste streams, almost no data are available on liquid processing wastes not dischargeable to water. This is particularly unfortunate since liquid wastes often present the greatest hazard potential if improperly handled, and they are with increasing frequency being excluded from landfill sites in many states.

Ultimately, the best way to check on the completeness of industrial waste output data is probably to trace the fate of all plant input materials in quantitative terms. Even a total mass balance approach, however, can be misleading. It might be possible, for example, to show by analysis that 102% of all raw material input to a process ends up in the final product, and still to find traces, but deleterious quantities of the input materials or their reaction or breakdown products in a waste water stream. One very simple illustration is the fate of process chemicals delivered to a plant in large paper sacks. Although the sacks would normally be "completely" emptied prior to disposal, sufficient chemicals always cling to walls and corners so as to virtually preclude the possibility of recycling the paper. In spite of uncertainties introduced by normal analytical errors, a demonstration that mass is conserved within a plant can at least assure that no major waste outputs have been inadvertently ignored in the course of a waste inventory.

Industry No. 0131 - Cotton

## Industry Characteristics

In 1929 over 43,000 acres of farm land were harvested yielding 164 pounds per acre, and producing almost 15 million bales. By 1971 harvested acreage declined to 12,355,000 acres but the yield of cotton was up to 438 pounds per acre, with a total production of 10,473,000 bales.

The leading cotton producing states are indicated below.

| | (acres in thousands) |
|---|---|
| Texas | 4735 acres harvested in 1971 |
| Mississippi | 1325 |
| Arkansas | 1140 |
| California | 742 |
| Alabama | 558 |
| Louisiana | 500 |
| Tennessee | 425 |
| Oklahoma | 396 |
| Georgia | 385 |
| S. Carolina | 320 |
| Missouri | 313 |
| Arizona | 285 |
| N. Carolina | 175 |

(Source: Agricultural Statistics, 1972, USDA)

## Waste Generation

Waste from the agricultural production of cotton and cotton seed derives from two main sources - farm waste and ginning plant waste. The latter is by far the more serious problem. In order to realize a profit a modern ginning plant must process a volume of 3,500 to 3,600 bales of cotton per year (about 1.8 x $10^6$ lbs/yr). Hence, except in the case of extremely large farms which might have their own plant, most gins serve a farming community. Handpicked cotton is relatively clean and produces only about 400 lbs waste /bale. Machine picked cotton is dirtier with total trash as high as 1,500 lbs/bale. This means a gin processing 15 bales/hr produces 22,500 lbs of waste/hr. (1)

More and McCaskill (2) give the following quantities and breakdowns for machine-picked, machine-stripped, and machine-scrapped cotton.

### Trash in Seed Cotton Harvested by Various Methods

| | Machine Picked | Machine Stripped | Machine Scrapped |
|---|---|---|---|
| Hulls | 29 lbs/bale | 397 lbs/bale | 329 lbs/bale |
| Sticks & Stems | 9 | 50 | 143 |
| Leaf & Dirt | 43 | 78 | 393 |
| Total | 81 | 525 | 870 |

Gin wastes are contaminated with pesticides, including volatile arsenic-containing compounds and defoliants. (2) In 1964 22% of the cotton crop was harvested by hand, 58% machine picked, 19% machine stripped, and 1% machine scrapped. (3) Hand harvesting is fastly disappearing in the U.S.

The cottonseed is valuable and is sold to cottonseed oil producers while some is returned to the farmers as crop seed. It is therefore a by-product and not a waste.

Waste Disposal -

Most gin trash is either incinerated or returned to the land. (3) The former has the potential of creating an air pollution problem, especially when one remembers that the gin itself produces a great deal of dust. (4) The disposal of gin wastes is complicated by their contamination with chemicals and infestation with weevils.

The value of gin waste as livestock feed is slight. Gin waste can be spread on the soil if it is not contaminated with weevils, either with or without composting. (5) In fact, it has been claimed, (6) that the spreading of the trash on the cotton fields can help to reduce wind erosion.

Simplified Classification -

| Waste Stream | Material Constituents | Chemical Composition |
|---|---|---|
| 70 | 70102 (stems, leaves, etc) | |
| (Vegetative product waste) | 83009 (Ag. chemicals) - | 01 (arsenates) |

## Industry No. 0161 - Vegetables and Melons

### Industry Characteristics -

In 1971, 3.181 million acres produced over 21 million tons of vegetables and melons in the United States. Approximately 48% was for fresh markets and 52% for processing.

The nationwide distribution is summarized in the following table.

| | | |
|---|---|---|
| North Atlantic | 313,420 | acres (New York = 136,010, N.J. = 98,050) |
| North Central | 852,770 | (Wisconsin = 324,360, Minnesota = 180,970) |
| South Atlantic | 576,150 | (Florida = 265,820) |
| South Central | 341,970 | (Texas = 214,140) |
| Western | 1,095,490 | (California = 672,950) |
| Total USA | 3,181,010 | |

### Solid Waste Generation -

Most of the solid waste generated is in the form of plant residues left in the field: leaves, stems, stalks, roots, vegetable rejects, etc. The unit quantities of waste per unit of harvest are extremely varied as indicated by the variety of products representated in this SIC category, and no statistics appeared in the literature surveyed. The quantity of residue left in the field can be considerable. For example three times the weight of an ear of corn, and four times the weight of a tomato are estimated residue weights in the field. (7)

Moreover, waste generation rates are increasing due to the growing use of highly indiscriminated mechanical harvesting devices. ( 8 ) Other wastes associated with vegetable production occur at the processing plants, and are discussed elsewhere.

### Waste Disposal -

Burning of field wastes continues to be a most common practice, except where prohibited by air pollution control regulations. Most field wastes are left in the field and plowed under. Properly managed, they can be of considerable compost value. Use of these wastes for compost in locations other than the generating field is not widely practiced.

The use of field waste as livestock feed is limited, although the usefulness of cellulosic agricultural wastes for this purpose can be improved by pre-digestion in caustic.

Simplified Classification -

| Waste Stream | Material Constituents | Chemical Composition |
|---|---|---|
| 70<br>(Vegetative product wastes) | 70102<br>(Stems, leaves, etc) | |

## Industry No. 0174 - Citrus Fruits

### Industry Characteristics -

Citrus fruit production is essentially limited to Florida, California, Texas and Arizona. Production summaries for the 1970-1971 season are given below. (9)

(quantities in 1000 boxes)

| | oranges | grapefruit | lemons | limes | tangelos | tangerines |
|---|---|---|---|---|---|---|
| California | 38,600 | 5,160 | 13,300 | 0 | 0 | 800 |
| Florida | 142,300 | 42,900 | 0 | 880 | 2,700 | 3,700 |
| Texas | 6,200 | 10,100 | 0 | 0 | 0 | 0 |
| Arizona | 3,560 | 2,520 | 3,160 | 0 | 0 | 390 |

### Solid Waste Generation -

The wastes are largely falls, trimmings, brush, and the containers used for the considerable quantities of pesticides and fertilizers applied.(10) By far the greatest quantities of solid waste are produced upon fruit processing (See also SIC No. 2037). This waste (peels, rags, seeds, etc.) comprises about 45 to 60% of the total weight of the fruit and at the height of the season Florida's citrus processing plants must dispose of 200-250 million lbs/week of waste material. (11)

### Solid Waste Disposal -

In the past most of the processing waste was returned to the groves as fertilizer, and covered with soil to discourage a fly nuisance. In recent years a great deal of the waste has been converted into cattle feed or citrus molasses -- 350,000 and 48,000 tons respectively in 1965-1966. (12) Leaching of fertilizers and pesticides from the groves and cannery effluents can also present serious water pollution problems.

### Simplified Classification -

| Waste Streams | Material Constituents | Chemical Composition |
|---|---|---|
| 70 | 70102 | |
| | 83009 | |
| 95 | 32000 | |
| | 83009 | |

Industry No. 0211 - Beef Cattle Feedlots

Industry Characteristics -

Beef cattle feedlots are primarily engaged in the fattening of beef for a period of at least 30 days. This operation is separate from the breeding, raising or grazing of beef cattle (Industry No. 0212).

In 1972 an estimated 117,916,000 heads of cattle were reported on American farms distributed as follows: (13)

| | |
|---|---|
| North Atlantic | 4.513 million |
| East North Central | 13.383 |
| West North Central | 37.367 |
| South Atlantic | 8.168 |
| South Central | 32.040 |
| Western | 22.191 |
| Alaska | 0.009 |
| Hawaii | 0.245 |
| Total | 117.917 |

Approximately 80% of the herds are raised for beef production with 20% for dairy production. Of approximately 94 million head of beef cattle, an estimated 13.8 million (14.7%) are being fattened for slaughter on grain and other feed concentrates. (14) While no specific figures were given for feedlot operations, it is presumed that most of the 13.8 million head of cattle reported on feed, are housed in feedlots.

Feedlots of 20,000 heads are not uncommon and 100,000 head lots have been constructed. (15)

Waste Generation -

A mature beef animal may weigh over 500 pounds, and generate about 52 pounds of manure per day. Thus, a feedlot with 10,000 head of cattle typically must dispose of 260 tons of fresh manure every day.(16)

Feedlot waste is particularly offensive: it stinks, it attracts clouds of flies and makes clouds of dust; (17) it contaminates adjacent waters (18) and it can pose a health hazard to humans. (19)

While the optimal use of the manure is probably fertilization of the very fields upon which the animals graze, the economics of packaging and shipping the manure back to the farms is less favorable than using artificial fertilizers.

Furthermore, large concentrated livestock and poultry operations do not usually have adequate land to distribute the bulk of their animal wastes.

Waste Disposal and Waste Management Alternatives -

There is a need to develop basic design criteria for handling manures in different parts of the country. Alternative disposal methods that are used, or can be used are listed below.

1. Composting and seasonal spreading on land.
2. Slurrying, lagooning and irrigation spraying of the fluid.
3. Drying, grinding, packaging and selling as an organic fertilizer and soil amendment.
4. Drying, comminuting and fermenting in a semi-solid fermentation to produce single cell protein which is then fed to livestock.
5. Slurrying, lagooning, aerating, fermenting, and cultivating selected algae; harvesting, drying and feeding the algae to livestock.
6. Anaerobic digestion in enclosed digestor tanks to produce methane gas chemically for local utility use, as a power source.
7. Hydrogenation in a closed oxygen-free auto clave to produce methane gas chemically for local utility use, as a power source.
8. Heat processing and distillation to produce crude oil and black granulated residue for conversion into building blocks (new).
9. Incineration with possible thermal recovery value.
10. Burying

Techniques are needed for odor control in connection with improved storage, handling and transfer technology. (20)

Guidelines for feedlot waste management, based on a realistic assessment of the problems and alternatives, were developed by the Seattle regional office of the EPA. (21)

Recognizing the seriousness of the animal waste disposal problem, several agribusiness companies and agricultural experimental stations are conducting research on developing new techniques of animal waste disposal and recycling. Some processes have recently been developed but most do not show that they are economically self-sustaining. There has been a substantial amount of research on the feasibility of feeding animal waste after it has been recycled. Some of the latest research on this subject was presented at the International Symposium on Livestock Waste which was held at Ohio State University in April of 1971. The Food and Drug Administration, however, has not granted its approval on feeding recycled animal waste.

Another approach being investigated is based upon the economics of fuel value recovery from manures. (22)

Scientists at the Bureau of Mines convert solid waste to fuel using pyrolysis and hydrogenation. In the pyrolysis method bovine manure is heated for six hours at 900°C for virtually complete conversion to gas, oil, and solid fuels. The gas has a fuel value of about 500 BTU per cubic foot; the oil 15,000 BTU per pound, and the solids 5000-13,000 BTU per pound which is similar to many coals. Hydrogenation produces a heavy paraffinic oil with 16,000 BTU/pound after only 20 minutes at 380°C in the presence of added carbon monoxide and steam. Hydrogenation offers the better commercial prospect according to the bureau since it will yield a single oil product that can be marketed in large volume. One ton of manure will yield three barrels of fuel oil.

The prognosis for solving the manure problem in feedlots or other areas where cattle are concentrated such as dairy farms is poor. (17)

Ideally, manures should not be considered a waste product at all, but a by-product of cattle management. At present the economics of the by-product results in a negative market price (i.e., the user of the product must be paid or subsidized to accept the product). Unless chemical fertilizer costs in relation to manure handling and transportation costs increase sharply due to market forces or governmental intervention, cattle manures could become a major contaminant to the environment, particularly as a source of water pollution, and a habitat for various diseases to livestock and man, as well as lowering the aesthetic value of the community.

Simplified Classification -

| Waste Stream | Material Constituents | Chemical Composition |
|---|---|---|
| 60<br>Manure | | |

## Industry No. 0241 - Dairy Farms

### Industry Characteristics -

Americans consume more milk and cream than any other type of foodstuff - 286 lbs/person-yr in 1967 compared to 176 lbs/person-yr for the next largest item, red meats. In 1967, U.S. dairies produced 59 billion lbs of milk and cream; 29 billion lbs of butter; 16 billion lbs of cheese; 13 billion lbs of ice cream and frozen desserts and 5 billion lbs of evaporated and dried milk. (23)

### Waste Generation -

The bulk of dairy farm solid wastes are the same as of those for feedlots (See SIC no. 0211), namely manure. In addition there may be some used bedding of straw, feed bags and other solid wastes from barns. The dairy processing facility may be located on the farm but more frequently is a plant to which the raw milk is carried.

Solid wastes are also produced in the processing plant. For example, about 600 million lbs/yr of whey (containing 0.9% protein, 0.3% fat, 4.9% lactose, and 6.9% total solids (24) is generated in cheese making, but this waste is almost always discarded in liquid form. By and large dairy wastes consist of various dilutions of milk. These liquid effluents are relatively low in solids about 4500 ppm (25), but have a high BOD.

### Waste Disposal -

As indicated above, wastes from milk processing are almost all handled as liquid streams, and many methods of waste water treatment have been reported. (26)-(30) Cottage cheese whey represents a major disposal problem when discharged to sewers and considerable effort has gone into economic methods for utilization. (31,32)

### Simplified Classification -

| Waste Streams | Material Constituents | Chemical Composition |
|---|---|---|
| 60 (Manure) | 63002 | |
| | 70103 | |
| | 41006 | |
| 64 | | |

Industry No. 0252 - Chicken Eggs

## Industry Characteristics -

In 1971 there were 321,821,000 chickens, hens, and pullets producing eggs on American farms distributed as follows: (33)

| | Birds | eggs/yr |
|---|---|---|
| North Atlantic | 45.086 million | 10.164 billion |
| East North Central | 44.540 | 10.160 |
| West North Central | 44.276 | 9.953 |
| South Atlantic | 67.016 | 15.007 |
| South Central | 66.076 | 14.364 |
| Western | 53.825 | 11.779 |
| Alaska | 0.030 | 0.006 |
| Hawaii | 0.980 | 0.211 |
| Total | 321.829 million | 71.644 billion |

Some poultry farms contain a million or more birds. (34) Modern poultry technology provides for maintenance of very high densities of birds with automated feeding techniques. An average egg farm has 100,000 birds.

## Waste Generation -

One chicken typically generates 0.25 pounds of wet manure per day. With high density farming, disposal of vast quantities of manure represents one of management's major problems. Apart from this enormous quantity of manure the solid wastes from the poultry industry are small, worn-out hardware and some used packaging material. (35)

Another disposal problem is dead birds -- about 1%/mo. in a laying hen production unit. (36)

## Waste Disposal -

A considerable amount of manure is waterborne to sewers, public streams, and/or lagoons for digestion. Some composting is practiced; sometimes the manure is merely air-dried. Wiley (37) recommends the design and engineering of composting systems as the best long-term solution.

The problems of poultry wastes in sanitary landfills have been discussed by Black. (38)

Many of the problems of manure management discussed under SIC 0211 (Feedlots) are completely analgous. The best use of the manure is processing for fertilizer, but the economics of processing, packing, storing, shipping and marketing are not very attractive at today's prices.

Simplified Classification -

| Waste Streams | Material Constituents | Chemical Composition |
|---|---|---|
| 60 | | |
| 61 | | |
| 10 | | |
| 95 | | |

## Major Group 10 - Metal Mining

As mentioned in Chapter I, the second major source of solid wastes in the United States, after agriculture, is mining. Millions of acres of land have been devastated by the accumulation of mountains of overturned earth from strip mining, mill tailings from processed washing plant rejects and processing plant wastes (39), (40). In 1969, the accumulated total of mining wastes was estimated at over 23 billion tons (41), and the rate of accumulation was about 1 billion tons/yr.

A good deal of effort has gone into means for utilization of mining wastes and some applications have been found but none with sufficient market to significantly reduce the solid waste burden. Building materials, such as bricks and light weight concrete can be produced, (42,43) and criteria have bean established for classifying mining wastes with respect to their suitability for conversion. (44) Classification criteria include: (45),

(1) quantity of waste available
(2) ease of transportation
(3) potential for growth in the area where the waste is generated
(4) presence of competitive building materials
(5) alternative uses that have been developed
(6) ease of processing

One study of 21 mining wastes in California found that only 9 had any commercial potential for the manufacture of calcium silicate building materials (46),(48). A study of the market potential for construction materials from mining wastes in six regions of the U.S. concluded that the potential would be greatest in the Southeast. (49)

An electrolytic method for recovering silver and mercury from silver mine tailings has been developed by the Bureau of Mines. (50) The Bureau has had a continuing program in the general area of ore utilization and recovery, and has generated many interesting results.

Climax Molybdenum, in opening a new mine in Colorado, planned for solid waste disposal as an integrated part of the total project(51), a practice which undoubtedly reflects the trend of the future.

Industry No. 1011 - Iron Ore Mining

## Industry Characteristics -

Mining is easily the largest source of inorganic, non-municipal solid waste in the United States. In 1965, the mineral and fossil fuel mining industries generated 419,571,000 short tons of mining waste and 293,000,000 short tons of tailings with iron being second only to copper and contributing 117,599,000 and 100,589,000 short tons of mine waste and of tailings respectively. It is estimated that 3,700,000,000 short tons of solid waste from iron mining and processing accumulated in the period from 1942 to 1965. (52) Sedimentary iron ores now being mined are relatively rich, being 20 to 41% iron metal. Hence the ratio of waste to metal is relatively modest. However, the Soviets are reportedly mining black sands containing less than 30% iron. (53)

## Waste Generation -

The mining wastes consist of vast quantities of overburden, rock, stripping, and low grade ore. In the Mesabi Range area of Minnesota alone, mining waste dumps cover some 13,800 acres. (54) Rail-hauled dumps tend to have a low profile but truck and conveyor belt hauled dumps can be mountainous. Since some of the wastes contain sufficient iron to warrant their exploitation at some future date depending upon technology and/or economics, these materials should not be discarded in a non-recoverable way. Similarly, "spent open pits cannot be filled with wastes for the lower grade ores left under the pit may some day become utilizable.

Lower grade taconite deposits are being increasingly exploited. In 1966, they accounted for 40% of U.S. tonnage. In 1975, they are expected to account for 75% (54) and the waste problem will be enormously aggravated. In Minnesota alone, there is a 45,000,000 ton open pit magnetic taconite reserve which corresponds to about 30 billion tons of future tailings or a pile 15 feet deep covering 1,000 square miles. (55) Nearly five tons of material must be mined to produce one ton of iron ore pellets from taconites. Furthermore, to make matters worse, the solid waste from taconite benefication is commonly discharged in a wet slurry that requires extensive settling basins. Tailings, especially from taconite processing, contain a finely divided fraction which can become an air pollution hazard if not physically stabilized.

## Waste Management -

Iron mining wastes are still iron ores and some effort has been devoted to upgrading them. Because of shipping costs, relatively little mineral waste is used for construction or fill.

The wastes contain little in the way of nutrients so re-vegetation of the dumps is slow. In the absence of extensive erosion from steepsides, dumps will begin to re-vegetate from natural seedings in 15 to 20 years. (54) Methods for accelerating the process have been studied by the Bureau of Mines. (56)

The Grace Mine in Morgantown, Pa. disposes of rock wastes on the slope of a low hill, and levels the waste with a bulldozer to form a terrace. the mill tailings are piped to an earthfill tailing dam. (57)

Simplified Classification -

| Waste Stream | Material Constituents | Chemical Composition |
|---|---|---|
| 50 | 51001 | |
| 81 | | |

## Industry No. 1021 - Copper Ore Mining

### Industry Characteristics -

Copper ores are much less rich in the metal than iron ores. The better porphyry copper deposits in the U.S. range from 2% downward. (53) Commonly, the ore to metal yield ratio is about 130:1. In other words 99% of the material mined is discarded as waste. Thus, while the total copper produced is much less than the iron produced, the solid waste generated is about twice as great: 286,000,000 short tons of copper mine waste and 174,000,000 short tons of tailings in 1965. The total wastes accumulated in the period 1942 to 1961 is estimated to be 7,356,000,000 short tons. (58) Copper mining and benefication produces more solid inorganic waste (much of it in the form of a slurry) than any other industry in the United States.

### Waste Generation -

The problems are similar to those already discussed for iron mining (SIC No. 1011, see above) but magnified by the greater amount of waste and aggravated by the fact that much of the copper ore waste is not inert chemically. It contains sulfides that upon leaching can be oxidized by air creating high acidity or other air and water pollution problems.

Of course, mining operations produce other solid waste (old machinery, old parts, etc.), but the quantities involved are insignificant compared to the mineral processing wastes.

### Simplified Classification -

| Waste Streams | Material Constituents | Chemical Composition |
|---|---|---|
| 50 | 51001<br>82005 | |
| 81 | | |

## Major Groups 11 and 12 - Coal Mining

### Industry Characteristics -

Based upon estimates of recoverable reserves (59) the nation's major coal states are:

| | |
|---|---|
| North Dakota | 175,327 million short tons |
| Montana | 110,848 |
| Illinois | 69,686 |
| Alaska | 65,042 |
| Wyoming | 60,343 |
| W. Virginia | 50,576 |
| Colorado | 40,340 |
| Pennsylvania | 34,736 |
| Kentucky | 32,665 |
| New Mexico | 30,729 |
| Ohio | 20,787 |
| Indiana | 17,332 |
| Utah | 16,112 |
| Missouri | 11,760 |
| Kansas | 9,339 |
| Alabama | 6,720 |
| Texas | 6,467 |

Several other states are reported with recoverable reserves ranging from 9 million short tons (Georgia) to Virginia with 4,914 short tons. The above figures include bituminous, lignite, anthracite, and semi-anthracite. Historically, Pennsylvania, West Virginia, Kentucky and Ohio have been the major suppliers (reserves depleted respectively to Jan. 1, 1970 were 28,716, 15,466, 6,988 and 4,914 million short tons), providing almost 80% of historically consumed coal in the United States.

The vast North Dakota reserve is exclusively lignite, most of it low in sulfur. The huge Montana reserve is about 39% lignite, 60% sub-bituminous, and 1% bituminous, and is also low in sulfur content. The vast north-western coal fields have hardly been mined.

The National Petroleum Council, (1972) (60) estimates that coal will maintain a stable 19-20% share of energy fuel resources in the United States through 1990. Annual consumption thus will increase from 519 million tons in 1970 to 933 million tons by 1985.

### Waste Generation -

Coal mining is very damaging to the environment and despite declining production this damage has been aggravated by increased strip mining. On an average nearly 13 yds$^3$ of overburden must be excavated to strip mine one ton of coal. Mine waste includes mine refuse, tunnel rock, silt and breaker waste. The breaker waste from the older dry technique is called culm and still contains appreciable amounts of commercially salable coal; the waste from modern wet breakers contains little usable coal. Wet breaking or other washing procedures make great water demands. (61) The solid waste is mostly $SiO_2$ (50-60%) with a smaller amount of $Al_2O_3$ (30-40%) and an even smaller percentage of $Fe_2O_3$ (3-10%).

In Pennsylvania alone over one billion tons of solid waste have accumulated above ground. In the U.S. as a whole coal mine solid wastes are deposited on some 800 banks, despoiling some 12,000 acres, and containing an estimated 900,000,000 $yd^3$ of material. (62) Some coal mining debris is used for landfill, construction and highway building, (63) but most of it simply accumulates. Coal mining wastes are particularly hazardous to the environment for they contain large amounts of oxidizable carbon and pyrites. As a consequence of the oxidizable carbon the banks can ignite, intentionally, accidentally, or spontaneously, and can become major sources of air pollution very difficult to extinguish. The pyrites, through bacterial oxidation and leaching processes are responsible for acid mine drainage - a process which has poisoned many of the natural waters in coal mining regions. (61) Legal responsibility and corrective action is often frustrated by the difficulty in resolving the ownership of the banks and/or the land they occupy. (62)

Waste Disposal -

In 1969 the Bureau of Mines surveyed the solid wastes that has accumulated from coal mining in Washington, Oregon, and Montana. (64) Refuse piles covered more than 2000 acres in the three state region, and it was anticipated that another 1000 acres of spoil banks would be generated over the next five years. In some cases cinder from burned refuse dumps found applications as a road fill and ceramic raw material. This type of application was recognized in the 1950's in work sponsored by the Pennsylvania coal industry. (65)

Some success has been achieved in stabilizing and reseeding coal refuse piles, through the use of fly ash from coal burning boilers. (66-68)

An interesting process was developed at a coal preparation plant in Marianne, Pa., whereby acid mine water is used to clean raw coal. Since the particular coal mine contained 30% of calcium and magnesium carbonates, the acid was neutralized as the coal was washed. (69)

A process for recovering usable coal from waste water slurries has been patented. (70)

Simplified Classification -

| Waste Stream | Material Constituents | Chemical Composition |
|---|---|---|
| 50 | 82004 | 29 |
| | 82005 | 30 |
| 81 | 82006 | 19 |

## Industry No. 1475 - Phosphate Rock Mining

### Industry Characteristics -

About 70% of the nation's phosphate rocks are mined in the State of Florida from land-pebble phosphate deposits of the Pliocene age. The pebbles are typically one-half inch in diameter. Typically the rocks are one-third phosphate, one-third clay and one-third silica sand. Mining depths are typically 30-35 feet, in broad strip mine sections.

In typical large scale operations (71) hydraulic guns are used to break up the rock matrix and slurry it down to 40% solids, for piping to a washer plant. Processing consists of the following steps:

1. Separation of coarse phosphate rock from clay, silica and fine phosphate. Various types of screens, log washers for washing the coarse or pebble phosphate, and hammer mills for breaking up the clay balls are used.
2. Two products are segregated out. One is in pebble form containing about 72% bone phosphate of lime (BPL). The other is a liquid concentrate containing about 76% BPL. The first comes right off the screens while the second is segregated from liquid waste products by hydro-separators and cyclones.

### Waste Generation -

The wastes include sand tailings which are useful for dam construction, land reclamation, and other construction, and clay based slimes which are extremely troublesome to manage. Large slime ponds are required since for every acre-foot of matrix mines, about 1.25 acre feet of slime is produced. Dams are usually constructed around mined out areas using sand tailings and clean overburden. Ponds are sometimes several thousand acres in extent and have a relatively short useful life of two to four years. Settling is very slow. Slimes that leave a plant at 4-5% solids consolidate to a maximum of 25-30% solids after years of settling. Reclamation of the ponded land for other purposes is thereby seriously impaired. Also, large quantities of phosphates are contained in the slimes since the separation process is not very efficient.

### Waste Disposal and Waste Management Alternatives

The costs of ponding phosphate slimes have been estimated at 24.5 cents/tons. (72) The Bureau of Mines has done a considerable amount of work on both utilization of the slimes and on better methods of disposal. While they have developed techniques for recovering phosphate and alumina values, the resultant residues still showed poor settling characteristics. (73) Bricks made from the slimes were expensive and of poor quality, but a method was developed for producing a lightweight ceramic aggregate with good properties for cement manufacture and favorable economics for the Florida market. (74)

Simplified Classification -

| Waste Streams | Material Constituents | Chemical Composition |
|---|---|---|
| 50 | 82004<br>(oxides) | 30 ($SiO_2$) |
| 81 | 51004<br>(clay) | |
| | 82004 | 30<br>29 |
| | 82003<br>(metal salts) | 00-26 (phosphate) |

## Major Groups 15 and 16 - Construction

### Solid Waste Generation and Disposal -

Solid waste pollution problems in the construction industry arise out of two areas -- the actual on-site work and that derived from the recovery of construction-related minerals.

On-site pollution has become a serious problem in recent years with the increased use of packaging in which almost everything used in the construction, from nails to refrigerators, come wrapped. Such materials are most frequently paper products and have traditionally been burned on the premises, thus increasing the problems of air pollution. A second major source of solid waste in construction comes from the disposal of excess materials -- such as oil and gasoline spills, broken brick, sawdust and lumber offcuts and concrete -- that are normally left on the site until pressure is brought on the contractor to remove and dispose of it. Related to the latter type of waste, but having a pecuniary value, are various minor pieces of equipment such as scaffolding, oil drums and planks that have lost their utility but have sufficient scrap value to be sold off to various dealers. Demolition construction provides large amounts of waste that are usually disposed of by landfill.

The industry is becoming increasingly aware of the need to protect the quality of the natural environment through use of controlled burning, prompt removal of solid wastes from the job site, (75) and recycling of rubble where possible. (76)

Materials recovery in building demolition activities plays an important role in the economics of the wrecking industry (Lipsett). (77)

### Simplified Classification -

| Waste Stream | Material Constituents | Chemical Composition |
|---|---|---|
| 95 | | |
| 10 | | |
| 94 | | |

## Industry No. 2011 - Meat Packing Plants

### Industry Characteristics

This sector includes slaughter houses, curing plants and meat packing plants for cattle, pork, and mutton. It also includes the making of sausages, bacon, cured and uncured hides, canned meats, cured meats, and several other products. Unless the slaughter and packing operations are combined, this sector is best studied by going to finer SIC designations.

In 1971 approximately 52.54 billion pounds of meat were prepared and processed under Federal inspection. (78) This total includes: cured, smoked or dried beef, pork and other; all forms of sausages; headcheese; fresh or frozen steaks, chops, roasts and boneless cuts; sliced meats such as bacon, hamburger and ground beef; frozen and unfrozen convenience foods; canned products; cutting and boning meats, horse meat products; edible fats and oils such as lard, tallow and oleomargarine.

### Waste Generation -

Packing plants produce relatively little that can be classified as solid wastes. Enormous quantities of water are utilized in the processing of meats, much of it draining the major solid waste residuals such as paunch manure, blood, and grease. Most of the animal is converted into some edible form. Viscera and bones are usually sent to rendering plants for conversion to grease or animal feed products. Hides and skins are sold to tanneries. Blood is recovered and sold.

The major waste disposal problem is thus related to the wastewater streams with high BOD content. (79-83) Various lagoon systems are in common use, but these require considerable land and appropriate drainage characteristics. (84) (85)

In 1969 Koenig, et al. (86) reported on the non-availability of reliable statistics regarding the generation of solid wastes in slaughter-houses and packing plants. They report that paunch manure disposal is viewed as a separate problem. Based on only seven interviews, they found two cases of the waste being converted, and two cases of disposal in a city dump.

Steffen (87) reports on chemical treatment and conventional activated sludge processes for treating meat industry waste waters.

These processes are being used increasingly, since the industry produces a highly organic, highly nitrogenous, biologically degradable waste-water with high concentrations of suspended and dissolved solids and grease. Also mentioned is the irrigation of fields with untreated waste water. Clearly a rigorous inventory of current practice would be useful and additional research into treatment and disposal methods is needed.

Another source of solid waste in the meat industry is the eventual discarding of the uniforms worn by meat workers.

Simplified Waste Classification -

| Waste Streams | Material Constituents | Chemical Composition |
|---|---|---|
| 60 | | |
| 64 | | |

## Industry No. 2032 - Canned Specialties (Baby Foods and Soup)

### Solid Waste Management Practice at Specific Plants -

### Campbell Soup Company

Campbell Soup Company operates major food plants in Camden, New Jersey (88) and Napoleon, Ohio (89), at which they have adopted somewhat different waste management practices.

Tables I and II summarize the type of solid wastes generated and the disposal methods used at the Camden and Napoleon plants respectively. Since the company strives to "look for the least cost method (of solid waste handling) consistent with good pollution control practice," it is interesting that they recover vegetable by-products in Ohio, but send all wastes to landfill in New Jersey.

### Gerber's Baby Food -

Gerber's also uses different methods of waste disposal in two of their plants. In one, wastes are ground and screened to separate liquids from solids. The former are piped to a river, the latter are transferred to hoppers for animal feed. The other plant is much larger and there are no natural waters in the area for handling the wastes. Solids are again screened out and sold as animal feed, but the liquids are spread on land through an irrigation farm seeded with crab grass. (90)

### Simplified Classification

Waste Stream

70
95
10
64

## TABLE I

## SOLID WASTE GENERATION AND DISPOSAL AT THE CAMPBELL SOUP PLANT IN CAMDEN, N.J.

| | | |
|---|---|---|
| Type of Waste | Fruit and vegetable seeds and skins - 30% liquid | Can remnants<br>Pallets<br>Cases<br>Paper (from labeling) |
| Handling | Emptied into open top roll-off 20-40 cu.yd. bins, sealed with rubber gaskets | Compressed in 2 cu. yd. compactors |
| Transport | Truck | Truck |
| Disposal | Private landfill, 7 miles from the plant | Same |
| Quantity | 10-20 cu. yds/hr, 18 hrs/day in season (August and September) | 50% of total plant wastes |

## TABLE II

## SOLID WASTE GENERATION AND DISPOSAL AT THE CAMPBELL SOUP PLANT IN NAPOLEON, OHIO

| Type of Waste | Spent Bone | Vegetable Trimmings | Obsolete Equipment | Saleable Paper e.g., labels | Other Paper (Meat boxes; plastic lined bags) | Tin Scrap | Floor Sweepings |
|---|---|---|---|---|---|---|---|
| | | | | | | | Cases<br>Plastic containers and liners<br>Wood<br>Obsolete equipment<br>Drumes, metal and fiber |
| **Handling** | Dried in a Louisville steam drier & packaged | Dried in a Heil gas drier | ? | Baled | - | - | - |
| **Transport** | Truck or rail | ? | ? | ? | - | - | 12 cu yd truck |
| **Disposal** | Sold | Sold to local cattle feeders; dried tomato trimmings sold through jobbers | ? | Sold to paper converters | Incinerated | Shipped to recovery mills | Public landfill |

## Industry No. 2033 - Canned Fruits, Vegetables, Preserves, Jams and Jellies

### Industry Characteristics -

Plants which fall under the 2033 category are concerned with the canning of fruits, vegetables, and fruit and vegetable juices; the manufacture of catsup, tomato sauce and related tomato products; and/or the manufacture of preserves, jams and jellies. The distribution of plants in the U.S. and the total employment by geographical area are summarized in Table I. (91) The industry is highly seasonal, and waste loads are generated within a relatively small harvest period.

While there is a very large literature source available on food processing wastes, most of it is concerned with liquid effluents and with methods for minimizing the BOD and SS in wastewater streams. (92-116)

### Solid Waste Generation -

In Table II, recent data (mainly 1968) are given for water consumed, waste water quality (BOD and SS), and solid residuals generated in the canning and freezing of fruits and vegetables. (117)

The solid residuals which would consist of peelings, pits, corn cobs, and husks, trimmings, overripe and off-quality produce would all be classified as Vegetative Product Wastes (Waste Stream No. 07), and would generally not be coded for specific chemical composition. If for any reason, it were important to distinguish corn cobs from apple peelings, (in order to assess disposability or recyclability, for example), a more detailed breakdown of the 07 category could be readily developed.

Additional amounts of waste, ultimately requiring land disposal, will also result from the water treatment system adopted. The liquid waste handling practice tends to vary from plant to plant and from location to location. The character and quantities of the solid wastes generated have not been well documented.

## TABLE I

### INDUSTRY NO. 2033 - NUMBER OF ESTABLISHMENTS AND EMPLOYMENT BY GEOGRAPHICAL AREA

| Geographic Area | Number of Establishments | No. of Employees (1000) |
|---|---|---|
| U.S., total | 1223 | 100.0 |
| New England | 48 | 1.2 |
| Maine | | |
| Massachusetts | | |
| Middle Atlantic | 200 | 13.7 |
| New York | | |
| Pennsylvania | | |
| New Jersey | | |
| East North Central | 299 | 17.9 |
| Wisconsin | | |
| Ohio | | |
| Michigan | | |
| Indiana | | |
| Illinois | | |
| West North Central | 42 | 3.8 |
| Minnesota | | |
| Iowa | | |
| South Atlantic | 238 | 17.0 |
| Florida | | |
| Maryland | | |
| Virginia | | |
| North Carolina | | |
| Georgia | | |
| Delaware | | |
| West Virginia | | |
| East South Central | 16 | 1.2 |
| Tennessee | | |
| Alabama | | |
| Kentucky | | |
| Mississippi | | |

TABLE I (Continued)

| | | |
|---|---|---|
| West South Central | 82 | 5.4 |
| Texas | | |
| Louisana | | |
| Arkansas | | |
| Oklahoma | | |
| Mountain | 36 | 1.5 |
| Utah | | |
| Colorado | | |
| Idaho | | |
| Pacific | 262 | 38.3 |
| California | | |
| Washington | | |
| Oregon | | |
| Hawaii | | |

## TABLE II

## WASTES FROM CANNING AND FREEZING OF FRUITS AND VEGETABLES

| | Raw Tons 1000 tons | Waste Water mil. gal. | BOD mil. lbs | SS mil.lbs | Solid Residuals 1000 tons |
|---|---|---|---|---|---|
| Fruit | | | | | |
| apple | 1000 | 5000 | 40 | 5 | 320 |
| apricot | 120 | 600 | 7 | 1 | 21 |
| cherry | 190 | 400 | 4 | 1 | 27 |
| citrus | 7800 | 23,000 | 31 | 55 | 3390 |
| peach | 1100 | 4400 | 66 | 11 | 270 |
| pears | 400 | 1600 | 28 | 8 | 120 |
| pineapple | 1000 | 500 | 20 | 8 | 450 |
| other | 400 | 3200 | 8 | 4 | 80 |
| Vegetable | | | | | |
| white potato | 24,000 | 9600 | 190 | 120 | 910 |
| asparagus | 120 | 1200 | 1 | 1 | 45 |
| lima beans | 120 | 1100 | 3 | 10 | 16 |
| snap beans | 630 | 2800 | 19 | 3 | 160 |
| beets | 270 | 1100 | 40 | 14 | 110 |
| carrots | 280 | 1100 | 15 | 11 | 150 |
| corn | 2,500 | 4500 | 62 | 25 | 1660 |
| peas | 580 | 2900 | 29 | 6 | 78 |
| pumpkin and squash | 220 | 700 | 18 | 3 | 150 |
| sauerkraut | 230 | 100 | 3 | 1 | 75 |
| spinach | 240 | 2200 | 6 | 2 | 37 |
| sweet potato | 150 | 1000 | 30 | 12 | (in other) |
| tomato | 5,000 | 10,000 | 60 | 20 | 400 |
| other | 1,300 | 5200 | 80 | 40 | 500 |

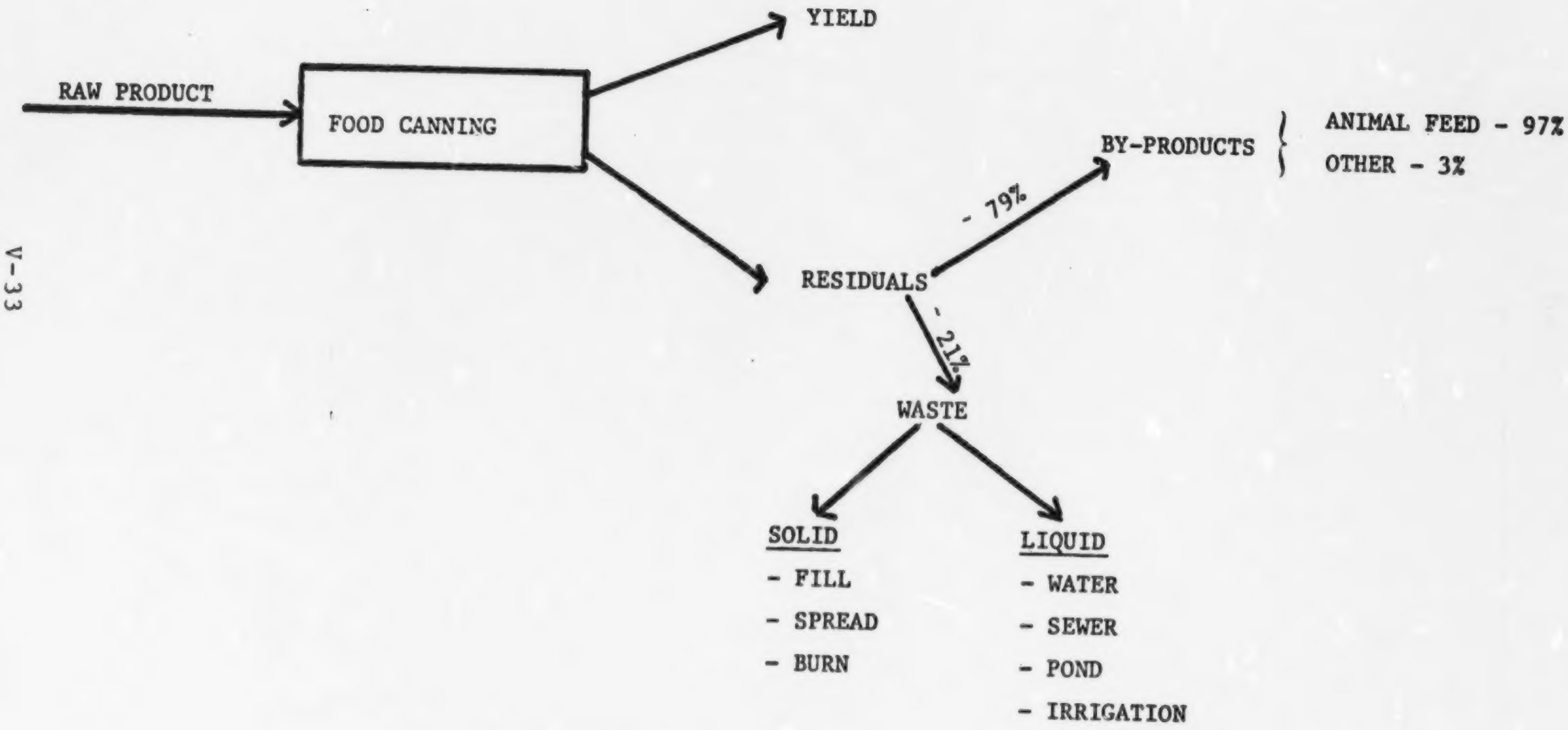

RAW PRODUCT
FOOD CANNING
YIELD
RESIDUALS
- 79%
BY-PRODUCTS
ANIMAL FEED - 97%
OTHER - 3%
- 21%
WASTE
SOLID
- FILL
- SPREAD
- BURN
LIQUID
- WATER
- SEWER
- POND
- IRRIGATION

FIGURE I. SIMPLIFIED MASS-FLOW DIAGRAM OF THE FOOD PROCESSING INDUSTRY( )

Solid Waste Management Practice -

A simplified diagram of the food canning industry is shown in Figure 1.(118)

About 79% of the solid residuals generated in fruit and vegetable canning and related processes are used as by-products. Animal feed accounts for 97% of the residuals used as by-products. Other by-products are charcoal, alcohol, oil, vinegar, and fertilizer, and there is a continuing effort to create useful products from many different types of food residuals. (119-125) More than 75% of the residuals used as by-products come from three products - citrus, corn, and white potatoes.

Source reduction as an alternative to by-product recovery has been applied in the processing of white potatoes with the development of infrared peeling. (126)

About 84% of the waste residuals from food canning (see Figure 1) are disposed of as solid waste. Nearly all of it either goes to landfill (not necessarily sanitary) or is spread on agricultural land (with or without disking). Incineration or burning is a very minor disposal mode (less than 1%). The remaining waste residual is disposed of in an aqueous medium, and would generally be dumped into receiving waters, sent to a sewage system, ponded, or used for land irrigation.

Simplified Waste Classification -

Waste Stream

70
64

## Industry No. 2051 - Bread and Other Bakery Products, Except Cookies and Crackers

### Industry Characteristics -

The 2051 industries are engaged in the manufacture of bread, cakes and other "perishable" baked goods. Industrial plants are distributed throughout the U.S. as shown in Table I, which includes employment figures. (127)

There are basically two types of bakery processes, different in both operation and waste characteristics. The first is a dry-baking operation, such as that associated with bread manufacture, where the mixing vats, baking pans, and sheets are all cleaned dry. The second type of operation is associated with the production of cakes, pies, doughnuts, etc., where pans and trays have to be washed and greased after each baking. (128)

### Solid Waste Generation -

There have been very few studies of bakery wastes, and most of these have been concerned solely with waste water effluent. The solid wastes resulting from pretreatment of the effluent in a New York State bakery are discussed by Grove, et al. (129) The average water consumption in the bakery which was studied was about 50,000 gal/day. Baking pans were washed after each use to remove grease, flour, sugar, and other materials. Containers used to transport fruits,nuts, milk and other bakery product additives were cleaned regularly. Floor washings contributed a further waste load. When an activated sludge water treatment unit was installed, the influent BOD, SS and pH of the combined washwater, after emulsion breaking, averaged about 2540 mg/1, 438 mg/1, and 4.7, respectively. Effluent BOD was reduced to about 12 mg/1, while the pH was increased to about 7.3. Waste solids from the treatment unit were estimated at 4370 gal/day, containing 1002 lbs of dry solids. The waste arose from three sources: 1) primary settled solids; 2) "curd" resulting from nitric acid breading of emulsified fats, greases, and soaps; and 3) waste activated sludge. These solids would generally require incineration or land disposal, although some of the sludge might be recycled. In any case, accumulated storage would be required, with aeration to prevent septicity.

Apart from the waste effluents described above, most bakeries schedule very closely so as to avoid waste. In the rare event that something goes wrong in the pre-baked stage, the product would probably be disposed of at a local piggery. Waste oils from the manufacture of doughnuts and other fried products would usually be filtered. The accumulated solids might be used as pig feed or sent to land fill. The oil is sold to rendering plants.

Simplified Waste Classification -

Waste Stream

64
84

## TABLE I

## GEOGRAPHICAL DISTRIBUTION AND EMPLOYMENT IN THE BAKED GOODS INDUSTRY NO. 2051

| Geographic Area | No. of Establishments | No. of Employees (1000) |
|---|---|---|
| U. S., Total | 4042 | 221.7 |
| New England | 410 | 16.9 |
| Massachusetts | | |
| Connecticut | | |
| Rhode Island | | |
| Maine | | |
| New Hampshire | | |
| Vermont | | |
| Middle Atlantic | 1064 | 49.4 |
| New York | | |
| Pennsylvania | | |
| New Jersey | | |
| East North Central | 746 | 46.0 |
| Illinois | | |
| Ohio | | |
| Michigan | | |
| Indiana | | |
| Wisconsin | | |
| West North Central | 344 | 17.4 |
| Minnesota | | |
| Missouri | | |
| Iowa | | |
| Kansas | | |
| South Dakota | | |
| North Dakota | | |
| Nebraska | | |
| South Atlantic | 414 | 31.4 |
| Florida | | |
| North Carolina | | |
| Maryland | | |
| Georgia | | |
| Virginia | | |
| South Carolina | | |

TABLE I (continued)

| | | |
|---|---|---|
| East South Central | 161 | 12.1 |
| Tennessee | | |
| Alabama | | |
| Kentucky | | |
| Mississippi | | |
| West South Central | 314 | 17.3 |
| Texas | | |
| Oklahoma | | |
| Louisiana | | |
| Arkansas | | |
| Mountain | 187 | 72.5 |
| Montana | | |
| Indiana | | |
| Colorado | | |
| New Mexico | | |
| Arizona | | |
| Utah | | |
| Nevada | | |
| Pacific | 402 | 72.5 |
| California | | |
| Washington | | |
| Oregon | | |
| Hawaii | | |

## Industry Nos. 2061 and 2063 - Cane Sugar and Beet Sugar

### Industry Characteristics -

Sugar Cane contains 11 to 15% sucrose by weight. A schematic flow diagram for the manufacture of raw sugar from the cane is shown in Figure 1.

Sugar beets contain from 13 to 17% sucrose. A flow diagram for the manufacture of beet sugar is shown in Figure 2.

### Solid Waste Generation and Disposal -

#### 1. Cane Sugar Manufacture -

The principal solid wastes in cane sugar manufacture are bagasse and filter cake. The latter may be a pollution hazard under certain circumstances. (130)

In Puerto Rico,(131) all the bagasse is used either internally as a fuel or in the manufacture of paper. The filter cake is spread on land as a fertilizer or soil conditioner.

In Hawaii, about a ton of soil and trash are discharged for every ton of sugar cane processed. (132),(133) In one plant at Waiphur,(132) about 60 tons/hour of bagasse leaves the mills and is used as fuel for the boiler. About 200 tons/day of filter cake, with a fairly high BOD, goes to a mud lagoon. Combustion of bagasse leaves a high carbon residue, which is sluiced with water. The fine carbonized bagasse floating in the sluice water makes it difficult to put the mill effluent through irrigation flumes. Another company in Hawaii has installed a pneumatic conveyor to blow bagasse into a storage bin with general trash. About 68 tons/day of bagasse, out of 1276 tons/day of other trash, is trucked to landfill. Thus it is by no means universally true that all bagasse is used.

#### 2. Beet Sugar Manufacture

Most of the papers on wastes in the beet sugar industry have concentrated on the water effluent. (135-141) The soil suspensions in the water used for conveying and washing the beets must either be removed, if the water is to be recycled, or may be spread on land via an irrigation system. The sludge, containing most of the impurities in beet juice, is adsorbed by calcium carbonate, and can be evaporated in a basin to produce a dry residue suitable for use as a soil conditioner. (135) Lime mud slurry, however, is normally pumped to a storage pond. Beet pulp at most plants is dried, pressed, and converted into pulp pellets, to be used as an animal feed together with molasses. Ashes from the boiler go to an ash pond in most cases.(140)

## Solid Waste Management Alternatives -

The search for means of utilizing bagasse has captured the imagination of many groups. In practice, there are probably two main uses: (1) as a fuel for steam generators, and (2) as raw material for the manufacture of paper and particleboard. The first step in any application would normally be dewatering, a process which can be quite costly.(143)

Since power is at a premium in many countries which grow and process large amounts of sugar cane, the burning of bagasse for energy recovery is attractive. East Germany has installed bagasse-burning boilers in Indonesia to supply production steam and electric power. In both cases, oil is available as a back-up fuel. (144)

For paper and particle board manufacture, the bagasse fibers must be separated from pith.(145) This is a troublesome process, which of course, leaves the pith as a solid waste. It is possible that pith might find application as an absorbent for molasses in the preparation of cattle-feed. (146) The East Pakistan Industrial Development Corporation has built a paper mill based on bagasse at Ishwardi. (147) Kimberly-Clark de Mexico has built an integrated bagasse mill for production of high quality paper products in Orizaba. (148)

The shortage of foreign exchange in Taiwan has stimulated the search for by-products from bagasse and other sugar manufacturing wastes. Bagasse is widely used in the manufacture of pulp and paper, hard board, insulation board, and particle board, In addition it is used as a raw material in acrylic process for preparing compost to fertilize the sugar cane in the fields. The process involves feeding molasses and yeast from the sugar mill to pigs, and then composting the pig manure with bagasse in the ratio of 3:1 by weight. (149)

Efforts to produce activated carbon from bagasse led to a distinctly inferior product, with a lower capacity for color removal than commercial adsorbents. (150)

During 1964, about 1.3 million tons of dried and molassed beet pulp were fed to animals in the U.S. The pulp is a potential raw material for production of water-soluble gum, pressed board, and pectin glue. The last is produced from beet pulp in the Soviet Union. (151)

Some work has been done in Germany on the regeneration of lime from beet sugar filter cake. (152)

One interesting process involves generation of a 65% methane - 35% gas mixture, a potential fuel, by fermentation of bagasse, cane trash, press mud, boiler ash, and hard sweepings. A manure or compost is generated as a by-product. (153)

Simplified Waste Classification -

| Waste Stream | Material Constituents | Chemical Composition |
|---|---|---|
| 65 | 82004 | 06 ($CaO$) |
| | 82003 | 06-06 ($CaCo_3$) |
| | | 06-18 ($CaSO_3$) |
| | 70500<br>(sugars) | |
| 70 | 70400<br>(bagasse) | |
| 64 | | |
| 51<br>(Flyash) | | |

FIGURE 1

MANUFACTURE OF CANE SUGAR

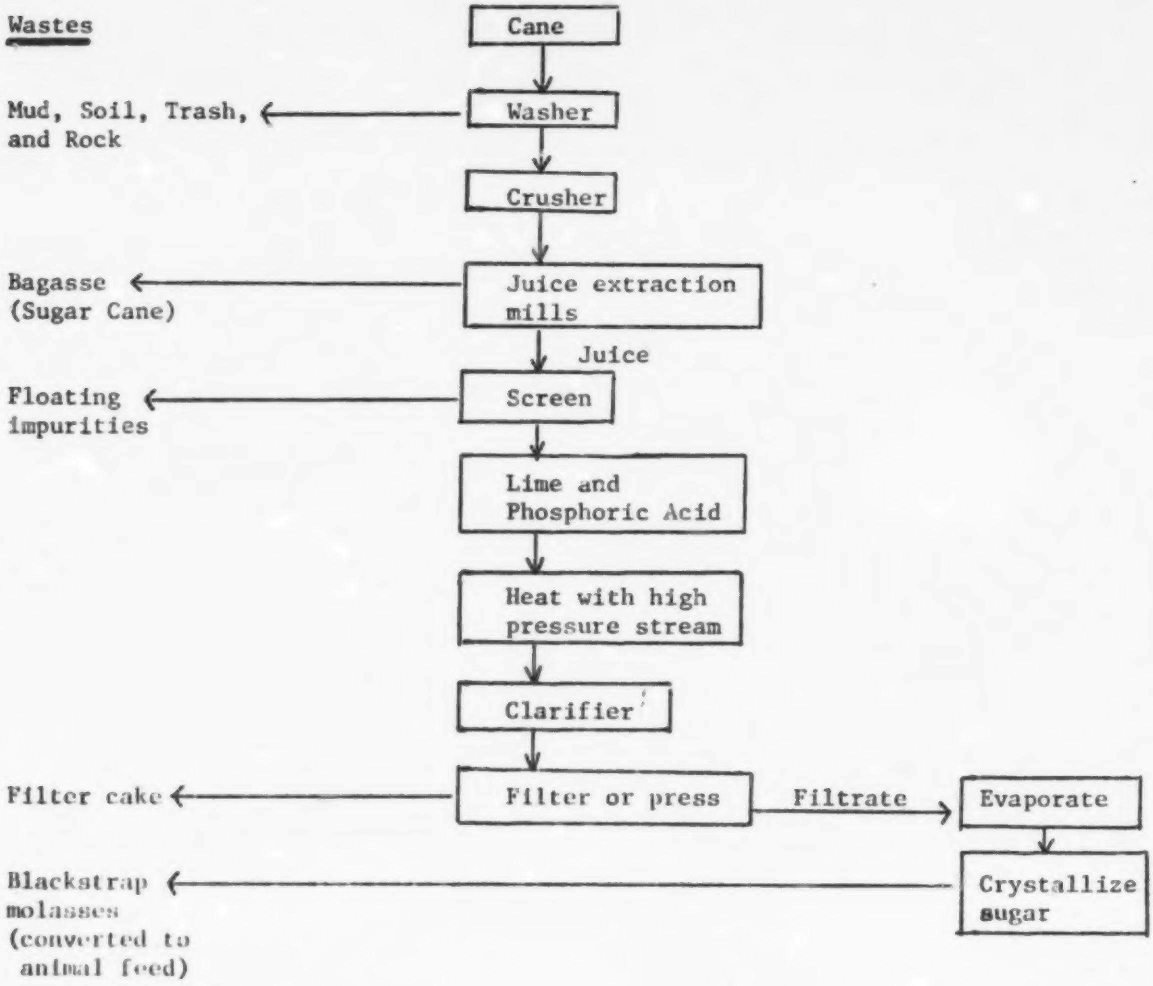
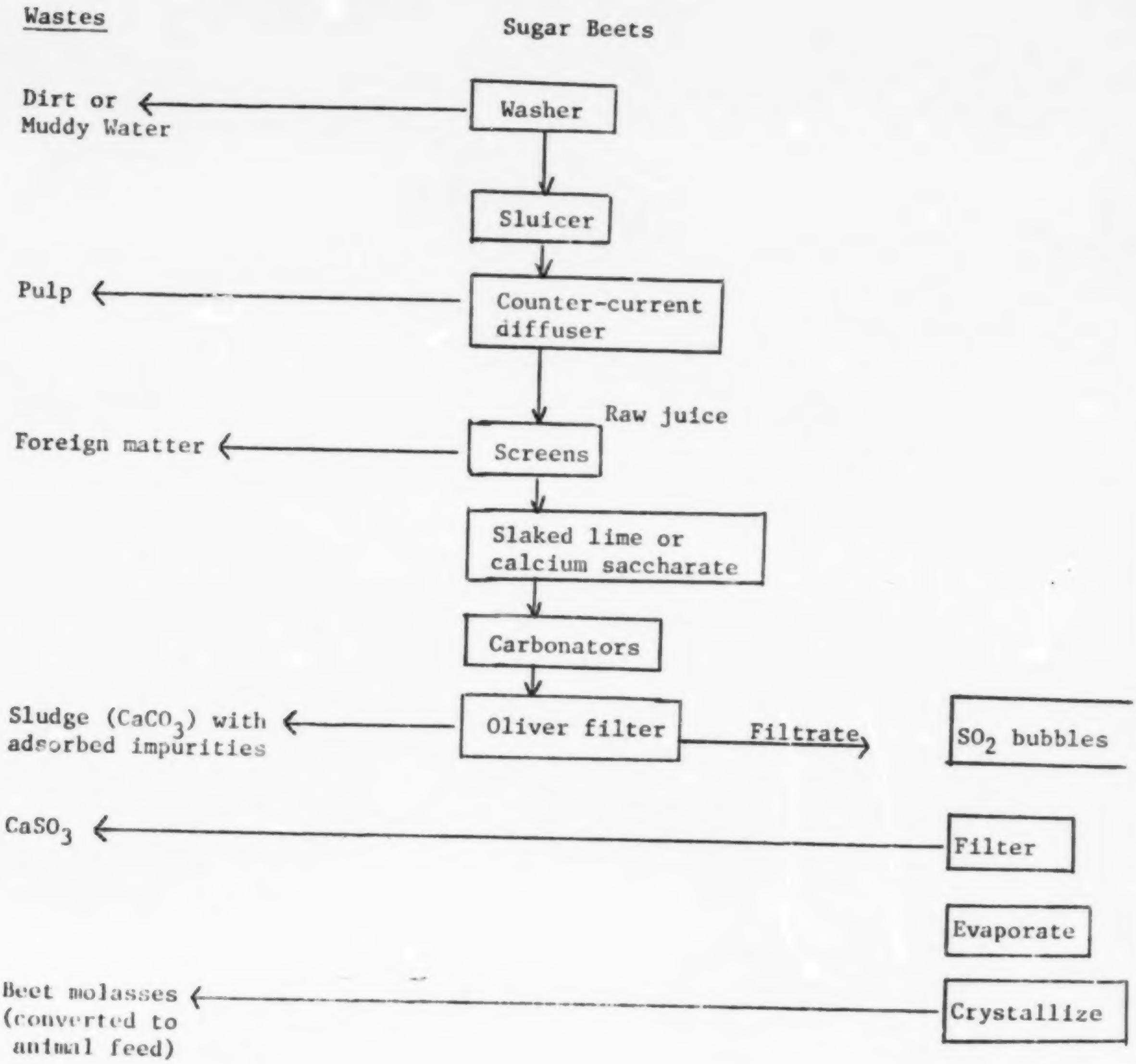

Wastes
Cane
Washer
Mud, Soil, Trash, and Rock
Crusher
Juice extraction mills
Bagasse (Sugar Cane)
Juice
Screen
Floating impurities
Lime and Phosphoric Acid
Heat with high pressure stream
Clarifier
Filter or press
Filter cake
Filtrate
Evaporate
Crystallize sugar
Blackstrap molasses (converted to animal feed)

FIGURE 2

MANUFACTURE OF BEET SUGAR


Wastes
Sugar Beets
Dirt or Muddy Water
Washer
Sluicer
Pulp
Counter-current diffuser
Raw juice
Foreign matter
Screens
Slaked lime or calcium saccharate
Carbonators
Sludge ($CaCO_3$) with adsorbed impurities
Oliver filter
Filtrate
$SO_2$ bubbles
$CaSO_3$
Filter
Evaporate
Beet molasses (converted to animal feed)
Crystallize

## Industry No. 2085 - Distilled, Rectified and Blended Liquors, Except Brandy

### Industry Characteristics -

Establishments engaged in the manufacture of alcoholic liquors by distillation and rectification fall under the general category of fermentation industries. In a broad sense fermentation involves the use of microorganisms (yeasts, bacteria, and molds) to bring about chemical conversion. The production of alcoholic beverages by fermentation of fruits and grains dates back to the earliest times. More recently, fermentation processes have been extended to the production of a wide variety of alcohols, organic acids, antibiotics, enzymes and other products.

Employment and geographic distribution of plants in the 2085 industry category are given in Table I. The largest number of plants are located in the East South Central region, primarily in Kentucky and Tennessee.

In the manufacture of distilled spirits (bourbon, rye, gin, whiskey, etc.), a mixture of grains (malt, rye, corn, oats, wheat, etc.), is ground and converted to a "mash", which is pumped to a large steel fermenter (see Figure I). Yeast is cultivated in a yeast tub under carefully controlled conditions and is used to initiate the fermentation cycle, which generally requires 30-50 hours. The liquor in the fermenters, when reaction is completed, is called a "beer." The beer, containing 6.5 - 11% alcohol by volume, is pumped to the upper sections of a beer still, where it loses its lighter boiling constituents. These are further purified and processed to produce the final product. The liquid discharged from the bottom of the beer still is known as "slop" or "stillage," and represents the major potential waste of the industry.

### Solid Waste Generation, Disposal and Utilization

Stillage usually has 5-6% total solids which contain all the protein, fat, fiber, vitamin, and mineral content of the grain. While these wastes at one time had little commerical value, they are now converted into premium feeds for beef and dairy cattle. In 1969, it was reported that only 1% of stillage in the U.S. was not recovered. About 85% of the stillage is dried by the distillers; 14% of it is fed to livestock undried. (154-15[7])

Most other distillery wastes are treated as aqueous effluent. The Hiram Walker distillery in Winfield, B.C. recovers both fusel oil esters and aldehydes from the distilling process.

Simplified Waste Classification -

Waste Stream

64

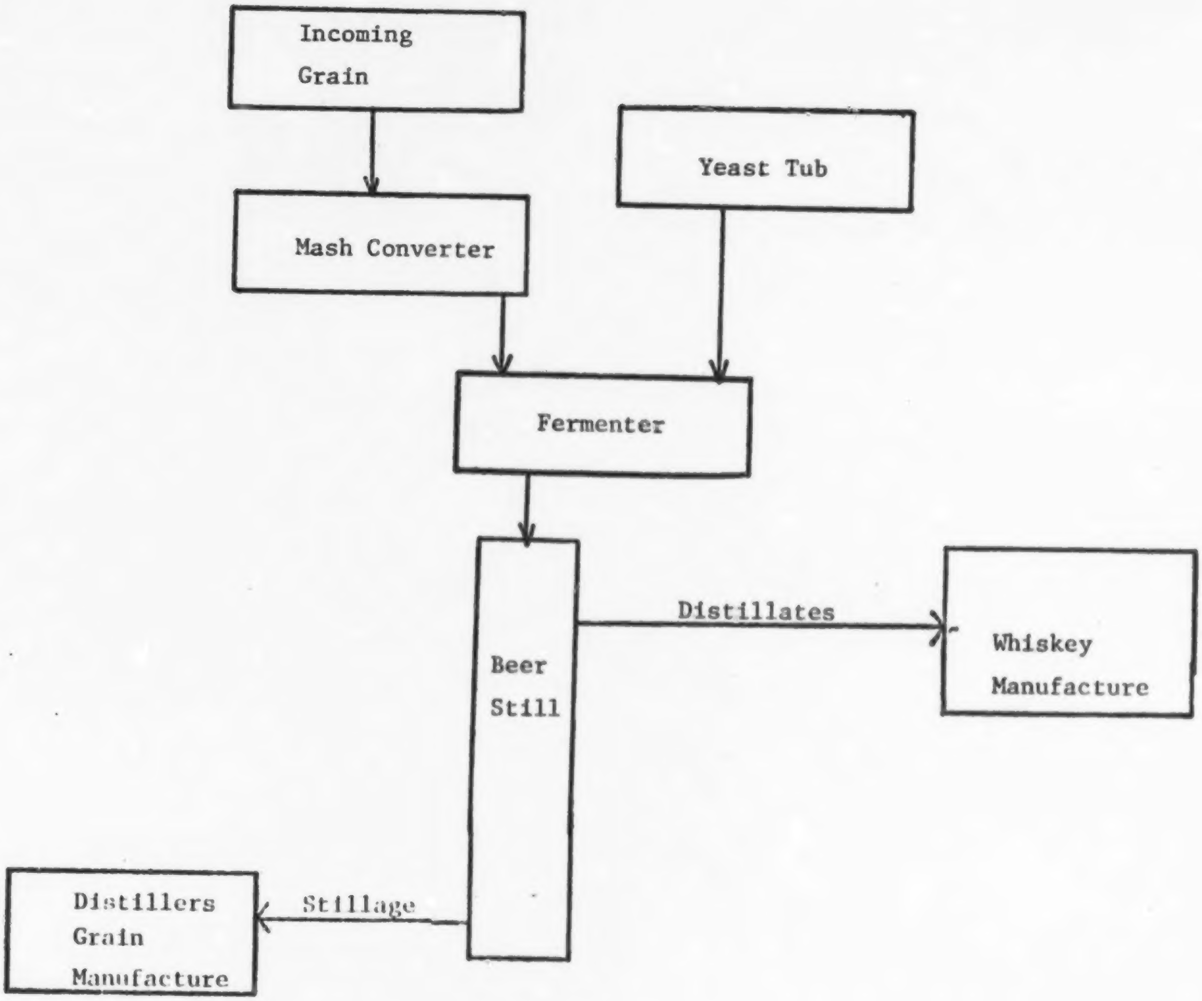
## TABLE I

## GEOGRAPHIC DISTRIBUTION AND EMPLOYMENT IN THE LIQUOR INDUSTRY NO. 2085

| Geographic Area | Number of Establishments | No. of Employees (1000) |
|---|---|---|
| U.S., total | 112 | 19.4 |
| New England | 10 | 1.0-2.499 |
| Massachusetts | | |
| Connecticut | | |
| Middle Atlantic | 17 | >2.5 |
| New Jersey | | |
| Pennsylvania | | |
| New York | | |
| East North Central | 15 | 6.0 |
| Illinois | | |
| Ohio | | |
| Indiana | | |
| Michigan | | |
| West North Central | 5 | 0.3 |
| Kansas | | |
| South Atlantic | 8 | 1.0-2.499 |
| Maryland | | |
| East South Central | 39 | >2.5 |
| Kentucky | | |
| Tennessee | | |
| Pacific | 16 | 0.5-0.000 |
| California | | |

FIGURE 1

SCHEMATIC FLOW CHART OF DISTILLED LIQUOR


Incoming Grain
Mash Converter
Yeast Tub
Fermenter
Beer Still
Distillates
Whiskey Manufacture
Stillage
Distillers Grain Manufacture

## Industry Nos. 2091 and 2092 - Canned and Cured, Fresh or Frozen Packaged Fish and Seafoods

Waste Generation and Disposal -

Seafood processing produces about 25,000 tons/year of residual solid waste, which is disposed of by landfilling (52%), spreading on the land (36%), or incineration (12%). An additional 94,000 tons/year of fish residual is disposed of in water.

Crab and shrimp wastes - shells, viscera, and meat scraps - have presented a very serious waste disposal problem in Alaska. Traditionally, wastes have been returned to the sea beside the processing plant, but they are depleting the oxygen in the waterways, are unaesthetic, and are occasionally washed on shore where they attract rats, flies, and other vectors. The possibilities for converting the residual into by-products appear to be uneconomic, even if feasible,(158),(159), and waste treatment would add to the costs in an industry whose supply and market has been declining.

In Hawaii, tuna cannery wastes flow into the municipal sewer system, although the solids content, 37% organic, is quite high, about 17,900 mg/l. (160)

A sea foods processing company in Brook Park, Ohio (161) incinerates the following types of wastes:

Moisture saturated corrugated and wax board (fish wrappings)
Saw blocks (used to cut frozen fish)
Steel strappings
Cafeteria trash

Wastes are collected in hand carts, and incinerator ash is hauled to a compaction trailer for disposal about 3 times/week.

Waste shells often left on land near shellfish processing plants present a serious waste disposal problem. They emit odors, attract flies, and are hard to bury and compact in a sanitary landfill. In an experimental project in Delaware, waste clam shells are being hauled by boat to an oyster growing bed.(162)

Simplified Classification -

| Waste Stream |
|---|
| 62 |
| 95 |
| 64 |

## Industry No. 2095 - Roasted Coffee

### Waste Generation and Disposal -

Approximately 528 million pounds of green coffee beans are roasted and converted to instant coffee in the U.S. annually. The production process generates roughly 288 million pounds of spent coffee grounds on a dry weight basis. Three methods have been used traditionally to dispose of the grounds: (1) discharge to a sewer along with the water effluent; (2) sanitary landfill; and (3) incineration. Direct discharge to sewers is highly undesirable, since the grounds have a high BOD and give the waste waters a dark color. Incineration is a fairly attractive method of waste disposal, particularly if it can be combined with some heat recovery. Dry coffee grounds have a heating value of about 9000 BTU/lb. (163)

Coffee grounds as generated contain about 75% moisture and this must normally be reduced to around 25% for efficient burning. The Nestle Company (164),(165) in Freehold, New Jersey has installed a $7,000,000 waste water disposal facility which reduces the BOD and removes the color of the waste water stream, while converting the coffee grounds to fuel for the boiler furnace that supplies steam to the system. Maxwell House, Division of General Foods (166), has installed "refractory cell" incinerators with heat recovery in at least eight plants in the U.S. and abroad. Although the moisture content of the coffee grounds is only reduced to about 55%, this appears to be sufficient for efficient heat recovery and achievement of autocombustion at high temperatures.

### Solid Waste Management Alternatives -

There is a patented process for converting coffee grounds to an ion exchange material for softening hard water. Spent grounds have also been investigated as potential animal feed supplements, but this application is highly controversial. The grounds can be composted, but so can many other things and the market for compost is very limited.

### Simplified Waste Classification -

| Waste Stream | Material Constituents |
|---|---|
| 70 | 70200 |

## Industry No. 2111 - Cigarettes

### Industry Characteristic -

According to the data in Table 1, from the 1967 Census of Manufacturers, cigarettes are manufactured in a small number of plants, located in the Southeast in Virginia, North Carolina and Kentucky.

After purchase, crude tobacco leaves are packed into wooden barrels, known as "hogsheads" and transported to a "stemmery." At the stemmery, the tobacco leaves are conditioned by steaming under vacuum, and then separated ballistically from the stem material in drums. Small pieces of tobacco (flags), attached to the stem are recovered and recycled into the main tobacco flow. The stems are usually used in the manufacture of tobacco sheets.

The tobacco leaves and flags are further processed to remove tobacco fines, sand and clay, and the final product is aged.

In cigarette manufacturing, the aged tobacco is cut, sized, and blended. A machine, known as a "maker" uses the tobacco, paper and cellulose to produce a continuous cigarette, which is then cut into proper size for packaging. The finished cigarettes are checked electronically and automatically packed. Defective cigarette are automatically rejected.

### Solid Waste Generation and Disposal -

Data on solid waste management at a stemmery, (167) believed to be representative, are summarized in Table 2, and related to the classification system in Chapter III.

Data on solid waste management at two cigarette manufacturing plants is summarized in Table 3.

### Solid Waste Management Alternatives -

The mixture of tobacco fines, sand and clay from stemmeries, is typically stored on site as indicated above, for eventual use as a fill material or soil conditioner.

Spindletop Research has explored in some detail the use of tobacco wastes, particularly stalks and stems for the production of commercial products.

### Simplified Waste Classification

| Waste Stream | Material Constituents | Chemical Composition |
|---|---|---|
| 70 | 51002 | |
| | 51004 | |
| | 70102 | |
| 91 | | |
| 95 | | |
| 10 | | |

## TABLE I

## GEOGRAPHIC DISTRIBUTION AND EMPLOYMENT IN THE CIGARETTE MANUFACTURING INDUSTRY NO. 2111

| Geographic Area | No. of Establishments | No. of Employees (1000) |
|---|---|---|
| U.S., total | 16 | 36.6 |
| South Atlantic | 12 | 28.3 |
| Virginia | | |
| North Carolina | | |
| East South Central | 4 | 8.3 |
| Kentucky | | |

## TABLE I

## GEOGRAPHIC DISTRIBUTION AND EMPLOYMENT IN THE CIGARETTE MANUFACTURING INDUSTRY NO. 2111

| Geographic Area | No. of Establishments | No. of Employees (1000) |
|---|---|---|
| U.S., total | 16 | 36.6 |
| South Atlantic | 12 | 28.3 |
| Virginia | | |
| North Carolina | | |
| East South Central | 4 | 8.3 |
| Kentucky | | |

## TABLE 2

## SOLID WASTE MANGEMENT AT A REPRESENTATIVE STEMMERY

## INDUSTRY NO. 2141

| | |
|---|---|
| Number of Employees | 500 |
| Plant Capacity | 50,000 lbs/tobacco/day |
| Terminal Solid Batch Data | |
| A. Combination of sand, fine, clay, and tobacco fines | |
| • Quantity (1967) | 4,145,000 lbs/yr |
| • Handling Management Attributes | |
| Collected by vacuum system | (012) |
| Stored in a large elevated tank | (08) |
| • Removal | |
| Collected 10-12 times/day in an open truck | (01) |
| • Delivery | |
| Hauled to an on-site ravine | (12) |
| • Disposal | (01) |
| • Material Constituents | |
| Sand (51002) | |
| Fine Clay (51004) | |
| Tobacco Fines (70102) | |
| B. Miscellaneous | |
| • Quantity | 572 lbs/day |
| • Management Attributes | |
| • Handling<br>Manually handled (014) | |
| • Removal<br>By truck (01) | |
| • Delivery<br>Municipal waste agency (01) | |
| • Disposal<br>City dump (01) | |

TABLE 2 (Continued)

| Material Constituents | Code | % Batch by Dry Weight | Origin Process (Code) |
|---|---|---|---|
| Luncheon and vending machine wastes | (91000) | 6% | (2050) |
| Woden hogsheads | (31005) | 94% | Packaging (2010) |
| Metal bandings | (11211) | | Packaging (2010) |
| Burlap bags | (41006) | T | Packaging (2010) |
| Off quality tobacco | (70102) | T | Processing (1100) |

# TABLE 3

## SOLID WASTE MANAGEMENT AT A CIGARETTE MANUFACTURING PLANT

| | |
|---|---|
| Number of Employees | 3600 |
| Terminal Solid Batch Data | |
| A. Wastes from automatic shredding of rejected cigarettes | |
| • Quantity | 50 cu yd/day |
| • Management Attributes | |
| • Handling | |
| Collected by vacuum system | (012) |
| Stored in a 50 cu yd container | (08) |
| • Removal | |
| By truck | (01) |
| • Delivery | |
| Private Contractor | (09) |
| • Disposal | |
| Private landfill | |
| • Material Constituents | |
| Cigarette paper | (32001) |
| Cigarette filter material | (32019) |
| Contaminated tobacco | (70102) - 6% by volume |
| B. Waste Metal | |
| • Quantity | 10 cu yd/week |
| • Management Attributes | |
| • Handling | |
| Stored in a 10 cu yd container | (014,08) |
| • Removal | |
| By truck | (01) |
| • Delivery | |
| Private Contractor | (09) |
| • Disposal | |
| Private landfill | (01) |

TABLE 3 (Continued)

| | |
|---|---|
| • Material Constituents | |
| Gears (11110) | |
| Sheet Metal (11200) | |
| Machine shop wastes<br>Maintenance shop wastes | Insufficient information to code |
| C. Miscellaneous | |
| • Quantity | 100 cu yd/day |
| • Management Attributes | |
| • Handling | |
| Stored in a 50 cu yd container | (014,08) |
| • Removal | |
| By truck | (01) |
| • Delivery | (09) |
| • Disposal | (01) |
| • Material Constituents | |
| General plants wastes | (90000) |
| D. Coupon or Premium Returns | |
| • Quantity | 42 cu yd/ week |
| • Management Attributes | |
| • Handling | |
| Fed to a Somat pulping machine | (02) |
| • Removal | (01) |
| • Delivery | (09) |
| • Disposal | (01) |
| • Material Constituents | |
| (pulped paper and rubber bands) | |
| Paper (32004) | |
| Rubber - trace (23019) | |

## Major Group 22 - Textile Mill Products

### Industry Characteristics -

Establishments falling under Major Group 22 are concerned with any of the following types of operations:

- Preparation of fiber and subsequent manufacture of yarn, thread, twine and cordage
- Manufacture of woven fabrics, knit fabrics, carpets and rugs from yarn
- Coating, waterproofing, fireproofing or otherwise treating fabric
- Manufacture of felts, laces, nonwovens and other textiles

The principal textile fibers are the natural fibers, cotton and wool, and the synthetics or man-made fibers, principally rayon, acetate, nylon, polyester, acrylics and modacrylics. In 1950, cotton fiber consumption was about 4.7 billion pounds, compared to about 0.6 billion lbs. for wool, and 0.3 billion pounds for synthetics. By 1969, synthetic fiber consumption had increased to about 4.9 billion pounds, while cotton had declined slightly and wool was down to about 0.3 billion lbs. (168)

### Solid Waste Generation -

While a great deal has been written about the nature and treatment of waste water effluents from textile manufacturing operations, (169-177) there is virtually no data on solid waste generation. Even those solids resulting from waste water treatment, which require subsequent disposal as solid wastes are given scant attention in the literature. From an analysis of the process Flow Charts for representative textile manufacturing operations, it is possible to estimate to some extent the nature of probable processing wastes, if not the quantities generated.

A simplified diagram of cotton goods manufacture is shown in Figure 1 by way of illustration. In "opening," thin layers of raw cotton, baled at the ginnery, are fed into machines which loosen separate and blend the fibers into a uniform mixture. The principal solid wastes are dirt and foreign vegetable matter (leaf trash, seeds, grass, etc). In "picking" the cotton is cleaned further and then formed into a flat, thick batt of randomly oriented fibers, known as a "picker lap."

"Carding" converts the picker lap into an untwisted "rope" of fibers of circular cross section, about one-inch in diameter. Solid Wastes include crushed impurities such as leaf trash, seed coat fragments, grass particles, and large neps (matted balls of fiber). If the carded yarn is "combed," short length fibers are removed and discarded. They are not true wastes, however, since they are widely used in lower grades of fabric and in the manufacture of cellulose base plastics. There would appear to be little solid waste in the drawing, spinning, and winding operations. Presumably there are some rejects when the yarn is inspected.

In any given mill, yarn will be either woven or knotted, not both. Skeins and quills are simply yarn packages of different kinds. "Warping" is essentially threading the loom. In "slashing," the warp fibers are coated with "sizing" to give them added tensile strength. Since sizes must be easily removable after weaving, they are generally water soluble or readily convertible to a water soluble condition. Modified starches are used for cotton. Other polymeric materials, particularly polyvinyl alcohol (PVA) and carboxymethyl cellulose (CMC) are used with man-made fibers. "Desizing" is done either in a sulfuric acid solution or in an enzyme bath. Since PVA and CMC are not biodegradable, they may be adsorbed on the sludge during effluent treatment and thereby end up as solid wastes.

"Scouring" as the name implies involves scrubbing out natural waxes, dirt, processing oils and some warp sizes with hot alkaline soap or detergent solutions. A suggested process modification, which illustrates how much more sensitive the industry is to water pollution than to solid waste disposal, is solvent processing. It is claimed that "the new non-aqueous systems reduce the pollutional load...by collecting the soluble natural impurities as an oily semi-solid at the purification stills, rather than discharging them to waste, and by eliminating the highly alkaline and soap-laden effluent from cotton scouring...and reducing the fresh water requirements from 15 gallons to 1/2 of a gallon."(178) Even if we assume that the solvents would be reclaimed, an "oily semi-solid" of any magnitude could present some serious disposal problems.

"Bleaching" is now done with hydrogen peroxide, which is ideal from the point of view of water quality, and which introduces no particular solid waste problem.

"Mercerizing" involves the treatment of cotton fabrics with caustic, which is frequently recovered.(179)

Dyeing yields a particularly refractory waste effluent. Some of the dyestuffs are toxic in themselves, and since they are designed to resist degradation and impart color to receiving waters even in very low concentrations, they will probably have to be treated chemically rather than biologically. This may cause them to end up in a sludge for land disposal. Carriers used to speed up the dyeing process, such as methylnaphtalene, chlorobenzenes, biphenyl, orthophenyl phenol, and benzyl alcohol, are also largely not biodegradable and may be adsorbed by the sludge in an activated sludge process. Their presence necessitates very careful handling of the sludge for ultimate disposal in order to prevent further contamination. Dyeing pastes, mixtures of dye, thickener, water, and other chemicals which are used to roll designs or patterns onto fabrics, contribute further to the dyeing effluent problems.

Today, there are all sorts of fabric finishes that impart special properties such as permanent press, oil repellancy, abrasion resistance, fire retardancy, etc. The finishes are usually polymers, and resins applied as emulsions. Most polymer emulsions are sensitive to pH, salt, agitation, etc., and may coagulate in waste streams. Suitable removal methods could again lead to a solid waste problem

Solid Waste Disposal -

Primary treatment of textile finishing wastes involves, among other things,, screening and sedimentation. The screening removes a mixture of lint, fibers, grit, and dirt which would probably be disposed of at a dump or landfill. Secondary biological treatment, as it is used today, yields a sludge which is particularly difficult to handle. On the average, 0.4-0.7 lbs of sludge (dry basis) is produced for every pound of BOD removed.(170) If the sludge is disposed of in landfill or by spreading on the soil, seepage or leaching can result in water pollution. Incineration is possible, but it must not result in air pollution.

Cotton fiber wastes from combing, carding and picking are by and large recyclable (173),(174) as are most wool wastes after some processing.(175) In the viscose-rayon industry many chemicals are recovered for reuse within the generating plant. Rayon waste for spinning and weaving operations is used for blanket manufacture and for batting and wadding (176) Nylon waste is reprocessed in the garnetting industry. (176)

A summary of typical recovery systems for various fiber processing wastes is given in Table I. (177)

Simplified Waste Classification -

| Waste Stream | Material Constituents | Chemical Composition |
|---|---|---|
| 70 | | |
| 88A | 82001<br>(acid) | 01($H_2SO_4$) |
| | 81004<br>(alcohol) | 48 (polyvinyl) |
| | 81021<br>(cellulose) | 02 (carboxymethyl) |
| 8813 | 83012<br>(Oils) | |
| | 51005<br>(dirt) | |
| | 83013<br>(soaps & detergents) | |
| 84 | 84201<br>(wet sludge) | |
| | 81006 | |
| | 81008 | |
| | 81013 | |

## TABLE I

## RECOVERY PROCESSES FOR VARIOUS FIBER WASTES

| Type of Waste | Possible Types of Recovery Processes |
|---|---|
| Cotton and Cotton linters | Sold to the paper industry.<br>Reinforcement of plastics, synthetic rubber, etc.<br>Reprocessing to yield sugar, fiberboard, adhesives, etc. |
| Polyester fiber | Remelting to produce yarn and staple (yields a low quality product) |
| Polypropylene fiber | Remelting for fiber or molded items |
| Cellulose acetates | Recycling to fiber by solution extrusion<br>Recycling with plasticizers for injection molding |

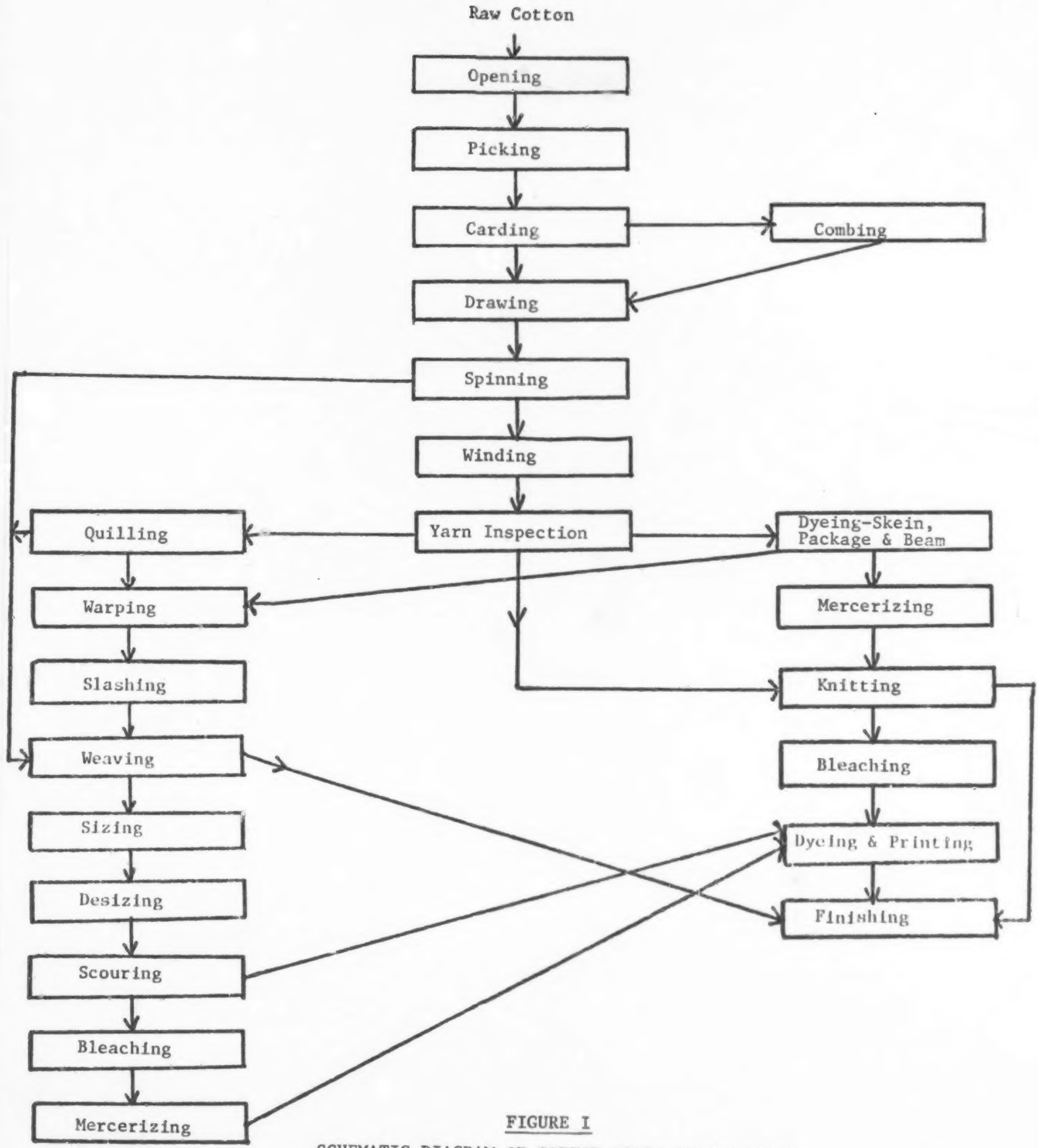

Raw Cotton
Opening
Picking
Carding
Combing
Drawing
Spinning
Winding
Quilling
Yarn Inspection
Dyeing-Skein, Package & Beam
Warping
Mercerizing
Slashing
Knitting
Weaving
Bleaching
Sizing
Dyeing & Printing
Desizing
Finishing
Scouring
Bleaching
Mercerizing

FIGURE I

SCHEMATIC DIAGRAM OF COTTON GOODS MANUFACTURE

## Major Group 23 - Apparel and Other Finished Products Made from Fabrics and Similar Materials

### Industry Characteristics -

Establishments within the Major Group 23 are engaged primarily in the cutting and sewing of purchased woven or knit textile fabrics for the production of all types of clothing, miscellaneous apparel and accessories, house furnishings (e.g., curtains, draperies, blankets, sheets, towels, etc), and other fabricated textiles.

Employment and geographical distribution for the 2311 segment of the industry (plants which manufacture men's, youths', and boys' suits, coats, and overcoats) are given in Table I.

### Solid Waste Generation -

In a study carried out by Combustion Engineering (190), seven plants falling within Major Group 23 were visited to obtain information on the types and quantities of solid wastes generated. The results are summarized in Table II. Published data on the solid waste output from two specific plants, a children's wear manufacturer (181)and a large clothing factory(182) are given in Table III.

### Solid Waste Management Practice -

About two-thirds of the processing waste from Group 23 industries is being sold as scrap. This material includes rags, cloth scraps, cuttings, clippings, and defective products such as soiled or ripped items, cutting errors, etc. New textile cuttings obtained by the scrap dealer from the manufacturers are generally presegregated. Certain grades of cotton cuttings, as specified by the National Association of Secondary Materials(183) are sold to the paper industry. In recent years, however, the availability of textile grades acceptable to the paper industry has declined considerably, due in part to the declining importance of pure cotton in textiles. Pure synthetic fiber cuttings (dacron, orlon, nylon, etc.) are sold to respinners.(184) Blended fabrics are sold for use as stuffing and backing materials. Large pieces of cotton clippings and rejects may be sold as wiping rags, but they constitute a very minor fraction of the total wiping cloth industry. In general, domestic markets for waste textile are decreasing, but export demand for synthetics and other textiles appears to be fairly strong.

Processing wastes from the Group 23 industries which are not sold, and other wastes generated by the industry are probably either dumped (including landfill) or incinerated. Avon Dale Manufacturing Co., (of Table III) had for many years hauled all of their non-recyclable solid wastes to a dumping area about a half mile from the plant where it was burned. The universally acknowledged undesirability of open burning led the company to explore alternative methods of solid waste disposal.

They found that the cost of shipment to the nearest sanitary landfill, 15 miles away, would have been about $9600/yr. They finally decided to install an essentially smokeless incinerator at an installed cost of $18,000.

Richman Bros., Co., also cited in Table III, found that landfills were moving farther away, this company too installed an incinerator, which meets air pollution codes, while reducing the volume of solid waste by about 96%. Although capital cost figures are not given, it is implied that they were fairly high, requiring a payout period of seven to eight years.

Simplified Waste Classification -

Waste Stream

45
95
91

## TABLE I

## GEOGRAPHIC DISTRIBUTION AND EMPLOYMENT IN INDUSTRY NO. 2311, SUITS, COATS AND OVERCOATS FOR MALES

| Geographic area | No. of Establishments | No. of Employees (1000) |
|---|---|---|
| U.S., total | 1003 | 135.9 |
| New England | 85 | 8.2 |
| Massachusetts | | |
| Connecticut | | |
| Rhode Island | | |
| New Hampshire | | |
| Middle Atlantic | 583 | 69.8 |
| New York | | |
| Pennsylvania | | |
| New Jersey | | |
| East North Central | 77 | 15.3 |
| Illinois | | |
| Ohio | | |
| Indiana | | |
| Wisconsin | | |
| West North Central | 39 | 4.4 |
| Missouri | | |
| Minnesota | | |
| Iowa | | |
| Kansas | | |
| South Atlantic | 103 | 18.3 |
| Maryland | | |
| Georgia | | |
| Virginia | | |
| Florida | | |
| North Carolina | | |
| South Carolina | | |
| Delaware | | |
| East South Atlantic | 39 | 12.2 |
| Kentucky | | |
| Tennessee | | |
| Alabama | | |
| Mississippi | | |

TABLE I (Continued)

| Geographic Area | No. of Establishments | No. of Employees (1000) |
|---|---|---|
| West South Central | 20 | 3.6 |
| Texas | | |
| Louisiana | | |
| Arkansas | | |
| Pacific | | |
| California | 51 | 4 |

## TABLE II

## SOLID WASTE GENERATION IN THE CLOTHING AND NEEDLE TRADES INDUSTRIES, MAJOR GROUP 23

| Waste Type | Estimated Quantities, lbs/yr |
|---|---|
| Plant Trash<br>Shipping Waste | 560,000,000 |
| Process Waste<br>Rags<br>Cloth Scraps<br>Cuttings<br>Selvedge<br>Trimmings | 421,000,000 |
| | 981,000,000 |

## TABLE III

## SOLID WASTE GENERATION IN TWO CLOTHING MANUFACTURING PLANTS

| | | |
|---|---|---|
| Plant Data | | |
| Name of Firm | Avon Dale Manufacturing Co., div. of Ekkey Industries | Richman Bros., Co., |
| Major products | Children's Wear | ? |
| Address | Olanta, South Carolina | Cleveland (east side) |
| Person Reporting | W. G. Mooren, Pres. | A. C. Goheen, Plant Manager |
| Date of Report | 1973 | 1970 |
| SIC | 236 | 23 |
| Number of employees | ? | 1500 |
| Solid Waste Output Quantity | 3000 lbs/day, 6 days/wk | 4000 lbs/day |
| Material constituents | Polyester (major)<br>Cotton<br>Cardboard | cloth scraps<br>Waste paper<br>plastic and paper wrapping<br>cartons<br>floor sweepings<br>wood crates<br>broken pallets |
| | Kitchen waste(some) | cafeteria waste |

## Industry No. 2421 - Sawmills and Planing Mills, General

### Industry Characteristics -

The primary activities of the 2421 industries are the sawing of rough lumber and timber from logs and bolts, and the resawing of cants and flitches into lumber. As indicated in Table I, there were 10,271 sawmills and planing mills in the U.S., employing 180,500 people at the time of the 1967 Census of Manufacturers. The principal establishments are in the South Atlantic, the East South Central, the East North Central, and the Pacific regions.

Figure I indicates schematically typical sawmill and planing mill operations, and the kinds of wastes generated at each step.(185) Cants may be prepared from debarked logs either by sawing off the rounded slabs from four sides, or by chipping. Since there is a market for wood chips, they are usually either produced directly or by chipping up the slabs.

### Solid Waste Generation -

The quantities of wastes or residuals listed on the left hand side of Figure I which were generated nationwide in 1970 are given in Table II.(186)

In spite of the relatively high percentages of wood milling wastes which are utilized, a considerable quantity remains for ultimate disposal. In a survey carried out by Combustion Engineering in 1969, the most common methods of waste disposal were teepee burning, dumping, and open burning. As indicated in Table IV, practice varied between the East and the West, and differed somewhat for each type of waste. In the South, where pulp mills exist in proximity with sawmills, viturally all chippable material is sold for pulp. According to state government personnel in California, the availability of waste wood chips brought the paper industry to that state. However, large quantities of wood chips are exported from California to Japan for paper manufacture.

### Solid Waste Management Alternatives -

Teepee burners are a source of smoke and particulate emissions, and large, integrated mills have tended to install more sophisticated smokeless facilities. In the State of Oregon, teepee burning has been outlawed, with the result that Lane County, which had 200 burners operating in 1956, had only 11 remaining in 1970. (187) The air pollution associated with burning, combined with the increasing value of wood, is expected to accelerate the trend towards more complete utilization of residue. Bark residue, in spite of considerable research efforts into means for fuller utilization, (188-194) remains a serious waste disposal problem. (195)

There are many papers on increased utilization of wood waste as fuel (196)-(198), pulp (199),(200) and other products. (201),(202)

Simplified Waste Classification.-

Waste Stream

30

## TABLE I

## GEOGRAPHIC DISTRIBUTION AND EMPLOYMENT IN INDUSTRY NO. 2421, SAWMILLS AND PLANING MILLS

| Geographic Area | No. of Establishments | No. of Employees (1000) |
|---|---|---|
| U.S., total | 10,271 | 180.5 |
| New England | 552 | 4.2 |
| Maine | | |
| New Hampshire | | |
| Massachusetts | | |
| Vermont | | |
| Middle Atlantic | 913 | 66 |
| Pennsylvania | | |
| New York | | |
| New Jersey | | |
| East North Central | 1,134 | 8.1 |
| Ohio | | |
| Michigan | | |
| Indiana | | |
| Wisconsin | | |
| Illinois | | |
| West North Central | 535 | 3.0 |
| Missouri | | |
| Minnesota | | |
| Iowa | | |
| Kansas | | |
| South Dakota | | |
| South Atlantic | 3,064 | 34.5 |
| North Carolina | | |
| Virginia | | |
| Georgia | | |
| West Virginia | | |
| South Carolina | | |
| Florida | | |
| Maryland | | |

TABLE I (Continued)

| Geographic Area | No. of Establishments | No. of Employees (1000) |
|---|---|---|
| East South Central | 1,662 | 22.9 |
| Tennessee | | |
| Alabama | | |
| Kentucky | | |
| Missippi | | |
| West South Central | 834 | 22.4 |
| Arkansas | | |
| Texas | | |
| Louisiana | | |
| Ohio | | |
| Mountain | 533 | 18 |
| Idaho | | |
| Montana | | |
| Colorado | | |
| New Mexico | | |
| Utah | | |
| Arizona | | |
| Pacific | 1,044 | 60.7 |
| Oregon | | |
| Washington | | |
| California | | |
| Alaska | | |

## TABLE II

## WASTE GENERATION FROM SAWMILL AND PLANING MILL OPERATIONS IN 1970

| Type of Waste (Classification Code) | Quantity | |
|---|---|---|
| | Million Cubic Feet (FI) | Million Tons (NPCC) |
| Bark (31002)** | 437 | 14-16 |
| Coarse residues - slabs, edges, chips, mill trim, ends | 1100 | 20 |
| Sawdust* (31007) | 379 | 6 |
| Shavings (31001) | 239 | 2.5 |

*Primary green sawdust

**The discrepancy between the volume and weight percentages of bark as calculated from the two separate references has not been resolved. The problem of interpreting units of measurement in the lumber industry is discussed in reference (C.E.).

## TABLE III

## UTILIZATION OF WOOD MILLION WASTES(FI)

| Type of Waste | % Utilization | Typical Uses* | Million Cubic Feet for disposal |
|---|---|---|---|
| Bark | 53 | Fuel (84%)<br>Miscellaneous (livestock, bedding, Mulch, etc.) (16%) | 206 |
| Coarse Residues | 87 | Fiber products (80%) pulp, particleboard, etc.)<br>Fuel (15%)<br>Miscellaneous (5%) | 143 |
| Sawdust | 64 | Fuel (73%)<br>Fiber products (19%)<br>Miscellaneous (8%) | 136 |
| Shavings | 82 | Fiber products (49%)<br>Fuel (43%)<br>Miscellaneous (8%) | 43 |

*Pacific Coast, 1970

## TABLE IV

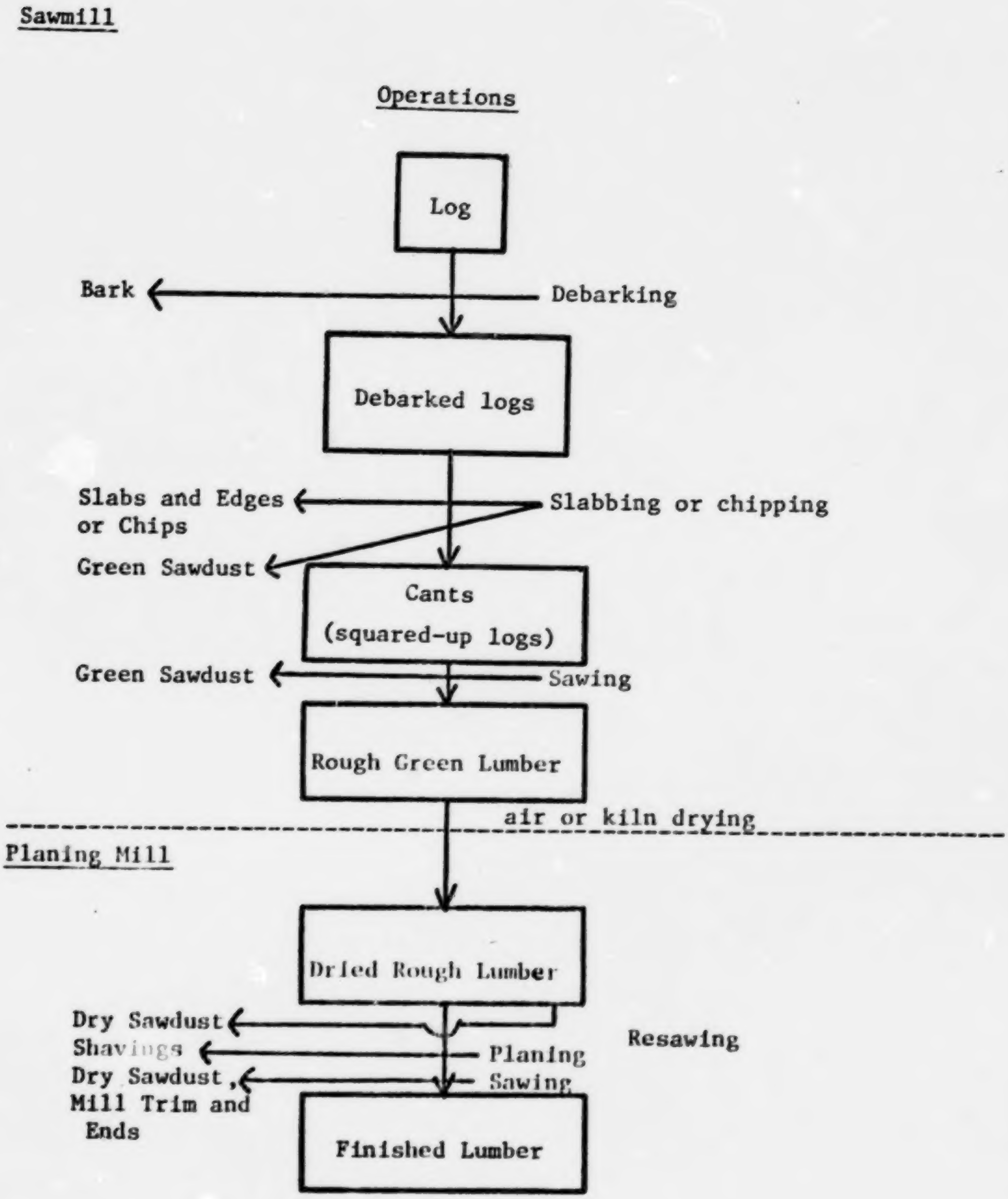
## DISPOSITION AND DISPOSAL OF WOOD MILLING WASTES(C.E.)

| Type of Waste | Sold | | Fuel | | Give Away | | Teepee Burning | | Dumps * | | Open Burning | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | West | East | West | East | West | East | West | East | West | East | West | East |
| Bark | 22 | 0 | 27 | 10 | 0 | 0 | 51 | 48 | 0 | 25 | 0 | 17 |
| Coarse Residues | | | | | | | | | | | | |
| Chips or slabs | 80 | 100 | 10 | 0 | 0 | 0 | 10 | 0 | 0 | 0 | 0 | 0 |
| Cut-offs | 67 | 0 | 0 | 0 | 0 | 0 | 33 | 0 | 0 | 0 | 0 | 0 |
| Sawdust | 18 | 10 | 45 | 35 | 0 | 12 | 37 | 16 | 0 | 17 | 0 | 0 |
| Shavings | 25 | 10 | 42 | 35 | 0 | 12 | 33 | 16 | 0 | 17 | 0 | 10 |

*Primarily self-dumping

FIGURE I

SCHEMATIC DIAGRAM OF SAWMILL AND PLANING MILL OPERATIONS AND WASTES


Sawmill
Operations
Log
Bark
Debarking
Debarked logs
Slabs and Edges or Chips
Slabbing or chipping
Green Sawdust
Cants (squared-up logs)
Green Sawdust
Sawing
Rough Green Lumber
air or kiln drying
Planing Mill
Dried Rough Lumber
Dry Sawdust
Resawing
Shavings
Planing
Dry Sawdust, Mill Trim and Ends
Sawing
Finished Lumber

Industry Nos. 2511, 2517, 2421, 2541 - Furniture and Fixtures (Wood)

Industry Characteristics -

Woodworking operations generate shavings, chips, and dusts which must be continuously removed from woodworking machines, collected, and disposed of. (203) Many furniture plants retain all shavings and sawdust, chop up remaining refuse, and store the material in a silo from which it is blown into a boiler for heat recovery incinerator. Installation of after-burner equipment helps solve the potential air pollution problems. (204) Small furniture plants sometimes give away coarse residues to employees for home furnaces and fireplaces. (205) There is a growing tendency to cope with the waste disposal problem through source reduction; i.e., more efficient utilization of the lumber to increase yield. (202) In addition, the wastes can often be sold to residue dealers for use in roofing plants, compounds, dunnage, hardwoods for smoked meat, bedding, etc.). Fine residues and dusts must be handled with some care since air-wood dust mixtures can be explosive. (203)

Simplified Waste Classification -

Waste Stream

30

## Industry Nos. 2611 and 2621 - Pulp and Papermills

### Industry Characteristics -

In 1970, U.S. industry produced about 53 million tons of paper and paperboard. In addition, the U.S. imported about 6 million tons of newsprint, resulting in a net U.S. consumption of some 57 million tons of paper and paperboard. In 1970 the industry consisted of about 450 companies operating 752 manufacturing establishments. Of the 450 companies, the top 20 account for 65-70% of the value for pulp, paper and paperboard shipment, while the top 50 firms account for about 90% of the output.

Pulp mill operations include:

1. Wood preparation - debarking, slashing and chipping of logs
2. Pulping - conversion of wood fibers by one of four processes;
    a. Mechanical - forcing logs against a grindstone in the presence of water

    b. Chemigroundwood - logs are impregnated with a hot chemical solution of sodium sulfite or Kraft liquor before grinding

    c. Kraft (Sulfate) - digestion of wood chips in sodium sulfide, hydroxide, carbonate, and sulfate

    d. Sulfite - digestion of wood chips in calcium or magnesium bisulfite solution with an excess of sulfur dioxide
3. Screening - removal of oversized wood chips
4. Washing
5. Thickening
6. Bleaching

Papermaking involves beating and refining, paper machine operation, converting and finishing.

### Waste Generation -

### Wood Preparation Operation

Pulp, paper and composition board operations used in excess of 65 million cords of wood in 1970, and generated about 12 million tons of bark waste. The technology has long been established to dewater (where necessary) and burn this bark for fuel. Most of the pulp mills are employing this practice. It has only been the small, marginal mills that have not found such a practice economical.

In addition to bark which is reclaimed and burned, a small amount enters the water stream via the traditional wet debarking operation. Screens are used to remove much of this suspended material but some eventually ends up in the effluent clarifier. Materials that end up at this point are generally not burned, so they contribute to the effluent clarifier sludge disposal problem.

New technologies and practices that will have an effect upon the solid waste originating in this operation include debarking in the woods, and the growing trend to mechanical (dry) debarking.

## Pulping Operations

In the Draft process, the spent sodium sulfite and caustic (black liquor) is stored and evaporated for recovery of chemicals. Dissolved organic matter is incinerated with heat recovery.

In the calcium based sulfite processes, the waste liquor, containing dissolved organics, cannot be economically utilized, since calcium sulfite does not decompose to $SO_2$, but forms $CaSO_4$, which is lost. The liquor has found application in road-binding, fermentation to ethanol or yeast, dispersant manufacture, oil well muds, concrete curing, and adhesives. (206),(207),(208)In the magnesium bisulfite process, the cooking liquor can be evaporated and burnt in a boiler to provide steam, MgO and $SO_2$. The MgO and $SO_2$ can be used to make fresh bisulfite liquor. (209)

## Screening, Washing and Thickening Operations

Unreacted wood, knots, fibers and foreign matter are removed during screening and washing. Thickening, or dewatering generated a waste water effluent.

## Bleaching

There are many bleaching systems, most of which involve some treatment with chlorine or chlorine dioxide. As a result the aqueous effluent streams tend to be quite high in chlorides. There has been no experimentation with oxygen and ozone bleaching, which would have far less of an impact on waste streams, but economics might prevent the use of these processes.

## Sludge

Most studies of waste generation in pulp and papermill operations have concentrated on waste water streams.(210),(211) The remnants of all the aqueous emissions, however, ultimately become effluent sludge. The composition of this material is highly variable and depends on the characteristics of the associated pulp or paper-making operation. Basically, the sludge is composed of a number of organic and inorganic materials. These are extremely fine particulates that are suspended in water, and not easily removed in conventional screening and reclaiming operations. The common underlying characteristic of this material is its ability to hold water.(212)

In paper-making, the waste water from the heating and refining operations may contain fillers, dyes, sizing, etc. Screening removes lumps of fiber or slime spots as a solid waste. A considerable portion of fine fibers and some filler also enter the waste stream during operation of the paper machine. In addition, a considerable amount of unusable paper is generated particularly of the coated variety, which is difficult to reprocess.

## Solid Waste Management

As previously indicated, the necessary waste water treatment processes required to bring pulp and papermill effluent into compliance with water quality standards generates a considerable quantity of sludge. Typically, the sludge is dewatered to facilitate handling, and is disposed of in landfill operations.

Numerous attempts have been made to dewater this material sufficiently for it to be incinerated. Unfortunately, the cost of this additional dewatering step or the cost of supplementary fuel to support combustion do not make incineration economically practical at this time. Numerous attempts have also been made to use this material as a soil conditioner or amender. However, the material lacks sufficient nitrogen value to be particularly useful in these applications. In fact, nitrogen must frequently be added to compensate for the nitrogen depletion as the cellulosic components of the sludge degrade.

There is at least one notable exception where the revenue from processing the sludge from activated lagoons has been sufficiently profitable to offset the added cost - namely, Milorganite. This material, the sludge from the city of Milwaukee sewage treatment plant, has been widely accepted as a soil amender and conditioner. In this particular case, however, the sludge is unique because it has been fortified with additional nitrogen compounds from the numerous breweries in the City.

Other selected examples of industrial sludges that have found application as soil amenders could also be cited. However, the major problem is the excessive amount that is available for comparatively few potential applications. In addition, present legislation restricts the application of industrial sludge as a soil amender to golf courses. The laws were passed to protect the public from any harmful bacteria that might remain in the material and be transmitted to people if used on house lawns. New technology is being developed that will destroy these potentially harmful bacteria.

## Fiber Recovery

At Weyerhaeuser's kraft mill in Everett, Washington, (213) a svstematic effort was made to locate points of fiber loss and to recover the fibers wherever possible. It was found that 27-73% of the fibers in effluent streams, depending on the source, could be recovered by use of hillside screens. The recovery system cost about $35,000 and value of fiber recovered was in the range of $16,000 -$20,000/year.

### Incineration of Bark, Debris and Sludge

In integrated timber, pulp and papermills, large quantities of bark and wood are generated unsuitable for pulping. The most practical disposal method is to convert it to fuel. (214)

The Great Lakes Paper Company at Thunder Bay was faced with the problem of a huge pile of bark (3000,000 cu. yd.) which has been accumulating for many years, as well as a sludge disposal problem. While they did have a system for burning bark in a furnace under a waste heat boiler, the old bark pile and the sludge would have had to be further dewatered to obtain satisfactory combustion in an ordinary furnace. To solve the problem, a fluidized bed incinerator with heat recovery and an effluent gas scrubber, (215)were installed. The cost of the system was about $1,000,000. The steam produced is valued at $300/day.

### Incineration of Sludge and Waste Paper

Reigel Paper in Milford, New Jersey has installed a system for shredding waste paper and for flowing it directly into the plant boilers. Sludge is dewatered and similarly blown into the furnaces. (216)

### Secondary Materials Utilization

It is possible to recycle paper waste as a raw material in the paper making process, although there are technical, economic and marketing problems. (217-228) Interstate Paper Corp. has found it possible to use reclaimed wood fiber and shredded stump-wood in the production of linerboard. (229)

### Simplified Waste Classification -

#### Waste Streams

30
84
31
85

## Industry No. 2711 - Newspapers, Publishing, Publishing and Printing

### Industry Characteristics -

Geographic distribution and employment in the newspaper industry in the U.S. are summarized in Table I. The 2711 SIC code encompasses all establishments engaged in publishing newspapers, whether or not they do their own printing. For our purposes however, the solid wastes generated in the printing operations are of primary interest, since publishing would only generate the usual office, cafeteria, packaging wastes, and general trash.

Most newspapers are printed by the relief process, although rotogravure is commonly used for the Sunday supplements, and web offset is gaining popularity for the printing or weeklies and smaller daily papers.

The image carriers for relief newspaper printing are virtually always curved stereotypes. These are manufactured in two main stages: (1) mat making and (2) casting. In mat making, a type form, the size of a newspaper page, containing metallic composition, photoengravings, and flat duplicate plates, is set up. The "mat" - a manufactured pulp sheet consisting of cellulose fibers with a smooth-coated malleable surface - is placed face down over the type form and molded by pressure alone or by a combination heat and pressure. The mat is formed into a curved position in a heated vacuum chamber. The formed and shrunk mat is trimmed and put into a casting machine where the curved stereotype is cast.

Newspapers are printed on inexpensive absorbent paper consisting of groundwood fibers with very little filler. News ink are mixtures of pigments, mainly carbon blacks, in a mineral oil vehicle to which may be added rosin oils, asphalts, pitches, rosin and oil soluble dyestuffs. News inks "dry" by penetration and absorption of the vehicle in the paper. Since news ink has no film-forming ingredients, it never clogs pipes and ink pumps.

Presswork in newspaper printing involves essentially attachment of the semi-cylindrical stereotype plates and running. Finally, the newspapers are folded, bundled, and shipped.

## TABLE I

## GEOGRAPHIC DISTRIBUTION AND EMPLOYMENT IN NEWSPAPER PRINTING AND PUBLISHING PLANTS, INDUSTRY NO. 2711

| Geographic Area | No. of Establishments | No. of Employees (1000) |
|---|---|---|
| U. S. Total | 8094 | 335.9 |
| New England | 387 | 24.5 |
| Massachusetts | | |
| Connecticut | | |
| Maine | | |
| New Hampshire | | |
| Rhode Island | | |
| Vermont | | |
| Middle Atlantic | 1043 | 68.5 |
| New York | | |
| Pennsylvania | | |
| New Jersey | | |
| East North Central | 1585 | 69.1 (?) |
| Illinois | | |
| Ohio | | |
| Michigan | | |
| Indiana | | |
| Wisconsin | | |
| West North Central | 1475 | 29.0 |
| Iowa | | |
| Missouri | | |
| Minnesota | | |
| Kansas | | |
| Nebraska | | |
| South Dakota | | |
| North Dakota | | |
| South Atlantic | 935 | 44.1 |
| Florida | | |
| Georgia | | |
| North Carolina | | |
| West Virginia | | |
| Virginia | | |
| South Carolina | | |
| Maryland | | |
| D.C. | | |
| Delaware | | |

TABLE I (Continued)

| Geographic Area | No. of Establishments | No. of Employees (1000) |
|---|---|---|
| East South Central | 474 | 13.2 |
| Kentucky | | |
| Tennessee | | |
| Mississippi | | |
| Alabama | | |
| West South Central | | |
| Texas | | |
| Oklahoma | | |
| Arkansas | | |
| Louisiana | | |
| Mountain | 456 | 13.8 |
| Colorado | | |
| Montana | | |
| Idaho | | |
| Arizona | | |
| New Mexico | | |
| Utah | | |
| Wyoming | | |
| Nevada | | |
| Pacific | 807 | 48.0 |
| California | | |
| Washington | | |
| Oregon | | |
| Hawaii | | |
| Alaska | | |

## TABLE II

## TYPES OF SOLID WASTES GENERATED IN VARIOUS PRODUCTION PROCESSES ASSOCIATED WITH NEWSPAPER PRINTING

| Type of Waste | Process Origin |
|---|---|
| Scrap "mats" - paper and plastic | Stereotype manufacture |
| Metal Dross - oxide-metal mixture (Cu,Mg, Zn) | Stereotype foundry |
| Metal Dross - lead | Not-metal typeset |
| Film negatives | Photoengraving |
| Cu, Mg, and Zn alloy plates | Photoengraving |
| Wood | Mounting of plates; pollets from press room |
| Empty chemical and/or ink containers | Photocopy<br>Presswork |
| Silver | Photocopy |
| Paper | Presswork - spoilage, trim, etc. |
| Rubber | Cylinder blankers, and roller coverings from press |
| Carbon tissue - mixture of gelatin, plasticizers, pigments, etc. on a paper base | Rotogravure printing |

Solid Waste Generation -

The EPA has sponsored a study on solid waste management in the printing and publishing industry, (230) in which the term "solid waste" was unfortunately strictly interpreted to mean "unused remnants from the printing production process that are not in the form of gas or liquid." A recent article (231)at least alludes to solvent wastes in the industry, which can present a difficult waste disposal problem.

The types of physically solid processing wastes generated in the printing industry are summarized in Table II.

Liquid wastes might include solvents, resins, dryers, oils, pigments, and etchants.

Solid Waste Management -

Scrap printing paper (about 3% of input) is salvaged on a fairly routine basis. Large firms may have vacuum systems leading from production equipment through shredders to balers where the paper is compressed into 100 lb lots.

Metal printing plates, reclaimed silver and dross is also salvaged. Non-salvagable wastes are generally collected and hauled to a dump or, rarely, incinerated on the premises.

Use of Secondary Materials -

A great deal has been written on the recycling of paper wastes. (232) Newsprint in particular can be made into newsprint again using a patented deinking process developed by Garden State Paper. (232) However, there are few recycling mills in operation. A 1972 article (231) reported that when newspapers in Louisville, Kentucky decided to recycle newsprint, they found that the nearest mill was located outside of Chicago. Not only did this mean high transportation costs, but the mill could only handle about 1000 tons/yr of newsprint from Louisville, while the plants were ready to supply 60,000 tons/yr.

Simplified Waste Classification -

| Waste Stream | Material Constituents | Chemical Composition |
|---|---|---|
| 31 | | |
| 95 | 82004 (oxides) | |
| 12 | 12103 (lead) | |
| (metal dross) | 12104 (zinc) | |
| | 12102 (copper) | |
| | 12119 (magnesium) | |

Major Group - 28 - Chemical and Allied Products

Industry Characteristics -

The 28 industries include the following SIC groups:

| Group No. | Name |
|---|---|
| 281 | Industrial Inorganic Chemicals |
| 282 | Plastics, Resins, and Inorganic Chemicals |
| 283 | Drugs |
| 284 | Soap and Detergents |
| 285 | Paints, Varnishes, Lacquers and Enamels |
| 286 | Industrial Organic Chemicals |
| 287 | Agricultural Chemicals |
| 289 | Miscellaneous Chemical Products |

The industries present, at one and the same time, some of the most challenging national solid waste disposal problems, and some of the greatest potential for innovative solid waste management practice, including resource recovery.

A countless number of chemical and allied products are manufactured each year, in enormous quantities, by a tremendous number of different processes. Furthermore, new chemicals and chemical formulations are constantly being developed, synthesized and marketed. The value of shipments in 1967 was 42.2 billion dollars. The largest number of industrial chemical plants are located in New Jersey, Texas, California, Ohio, Pennsylvania, and Illinois. (233) The SIC Group 28 industries employ 854,000 people, or 4.4% of all employees engaged in manufacturing. (233)

Solid Waste Generation and Disposal

We will confine our discussion for the most part to processing wastes i.e., those generated directly from the manufacturing operations. The Research Corporation of New England (TRC) did a fairly extensive study of solid waste management in the chemical industry. They classified the wastes generated into six categories as shown in Table I. The categories, while serviceable and for the most part mutually exclusive, are not entirely consistent. Sludge and tars represent physical form; filter residue and off quality product represent process origins; and flyash is a particular type of waste material.

There are probably over a million chemicals produced and almost as many waste products. (233) There is no comprehensive tabulation of the multitude of waste generated in chemical production processes, including physical form, materials composition, chemical analysis, and properties that relate to various disposal modes. Industrial companies, such as DOW in Midland, Michigan have made a detailed survey of the wastes generated in their own production processes, but the information is generally con-

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## TABLE I

## PROCESS WASTE CATEGORIZATION USED BY TRC

| | |
|---|---|
| Sludge: | A soft mud, slush or mire usually resulting from dewatering of slurries without filtration. |
| Filter residue: | Material removed from the process stream by a filtering device (filter cake). It sometimes contains the filter media also. |
| Tars: | An organic residue of mixed chemical composition usually appearing as a still bottom or distillation residue. |
| Off-quality product: | A chemical product not meeting the commercial specifications for the particular product and not of sufficient economic worth to warrant further purification or recovery. |
| Flyash: | The residual solid ash remaining from the combustion of coal, either as furnace bottom ash or that caught by stack emission controls. |
| Other: | Any chemical waste that does not fit into one of the above categories. Examples here are: spent catalysts; contaminated containers, etc. |

Industry No. 2812 - Alkalies and Chlorine

Industry Characteristics -

In 1967, there were 44 plants in the U.S. manufacturing alkalies and chlorine, employing a total of 19,200 people, with a value added of $419 million. (233) The principal products are chlorine, caustic soda (NaOH), soda ash ($Na_2O$), and sodium bicarbonate. The major wastes and waste generating processes are summarized in Table I.

Waste Disposal Practice

There is not a great deal of specific information about waste disposal practice in the industry. Of the various components of the diaphragm cells, the spent graphite anodes are salvaged; the cathodes may be salvaged or dumped; the used cell bodies are piled up on site, with the hope that they might be used in some sort of construction fill application. Other wastes are very likely disposed of ultimately in a landfill. Fairly intensive studies on reducing mecury emissions from mercury cells were carried out in Sweden(234) and by Sobin Chlor-Alkali in Maine.(235)

The solid wastes generated by the Solvay Process Division of Allied Chemical are deposited in waste beds on the shores of Onondaga Lake at Solvay, New York. The material is a white sludge, layered with grey; it is high compressible, and high corrosive. Its consistency varies from wet and soft to firm. Syracuse University did a study on the possibilities for utilizing the waste beds, either by promoting the development of vegetation or as a development site for light buildings, parking lots, and highways. (236)

Simplified Waste Classification -

| Waste Stream | Material Constituents | Chemical Composition |
|---|---|---|
| 10 | 41004 (asbestos) | |
| | 82006 (graphite) | |
| | 52203 | |
| | 82002 | 02 (NaOH) |
| 81 | 82003 | 02-06 ($CaCO_3$) |
| | (salts) | 05-06 ($MgCO_3$) |
| | 82002 | 07-19 ($BaSO_4$) |
| | | 10 ($MgCOH_2$) |
| | | 04 ($FeCOH_2$) |
| | 12107 (Hg) | |
| 80 | 82003 | |
| | | 02-27 (NaCl) |
| | | 06-27 ($CaCl_2$) |
| | | 06-06 ($CaCo_3$) |

## TABLE I

## WASTE GENERATION IN INDUSTRY NO. 2812, ALKALIES AND CHLORINE

| Product | Process | Type of Waste | Process Origin |
|---|---|---|---|
| Chlorine and Caustic Soda | Electolysis - Diaphragm Cells | • Asbestos* | Clogged diaphragms |
| | | • Crimped steel wire | waste |
| | | • Graphite plates | Waste anodes |
| | | • Concrete slabs | Waste Cell bodies |
| | | • $CaCO_3$, $MgCO_3$, $Mg(OH)_2$, $Fe(OH)_2$ sludge | Brine purification |
| | Electolysis - Hg cells | • $BaSO_4$m $CaCO_3$, $MgCO_3$m $Mg(OH)_2$ Hg sludge* | Brine purification |
| | | • Graphite sludge | Filtration of purified brine |
| Soda Ash and Sodium Bicarbonate | Solvay | • $CaCO_3$, $Mg(OH)_2$, $Fe(OH)_2$, sludge | Brine purification |
| | | • Sands and $MgCO_3$ slurry | Lime Slaker |
| | | • Waste liquor - NaCl, $CaCl_2$, $CaCO_3$ | Amonia recovery |

*Hazardous material

## Industry No. 2813 - Industrial Gases

### Industry Characteristics -

Acetylene is the only common industrial gas whose manufacture gives rise to significant quantities of solid waste. The three major acetylene production processes and the wastes produced from each are summarized in Table I. The 10% lime slurry generated in the wet calcium carbide process is almost invariably pumped to diked areas, where it concentrates to some degree. Recently it has found application in acid neutralization processes and in wet scrubbing of flue gas to remove sulfur oxides.

The carbon black filter cake from the Sachsse process presents a particularly difficult waste disposal problem. The carbon is graphitic and does not burn well below 1600-1800°F. At those temperatures, the diatomaceous earth filter tends to fuse, making it useless. The removal of carbon from the soot effluent can be very troublesome, and a number of patents have been issued on decarbonization processes.

### Simplified Waste Classification -

| Waste Stream | Material Constituents | Chemical Composition |
|---|---|---|
| 81A | 82002 | 03 $(Ca()H)_2)$ |
| 89 | | |
| 82 | 82006 (graphite) | |
| | 51005 (diatomaceous Earth) | |
| 8113 | 82006 | |

## TABLE I

## SOLID WASTE GENERATION IN THE PRODUCTION OF ACETYLENE

| Process | Type of Waste | Process Origin |
|---|---|---|
| Wet $CaC_2$ | $Ca(OH)_2$ slurry - 90% water | $CaC_2 + H_2O \rightarrow Ca(OH)_2 + C_2H_2$ (excess water) |
| Dry $CaC_2$ | Lime | As above (limited water) |
| Wulff-thermal decomposition of hydrocarbons | Tars | Pyrolysis |
| Sachsse - Partial | • Carbon black filter cake<br>• Sooty water (52 lbs of carbon black/ton of $C_2H_2$) | Soot filter<br>Quenching of gases |

Industry No. 2816 - Inorganic Pigments

## Industry Characteristics

Manufacture of $TiO_2$, the largest selling white pigment, $BaSO_4$ and ZnO, generate substantial quantities of solid wastes, mainly ore impurities as summarized in Table I. The mud from the sulfate proudction of $TiO_2$ is disposed of in landfill or sometimes by deep ocean dumping. The wash waters containing $TiO_2$ fines, are sometimes lagooned, and the $TiO_2$ which settles out is periodically dredged and stored for possible recovery. The clinker from ZnO production is either dumped, or occasionally used to manufacture Spiegeleisen, a manganese alloy with applications in steel making.

## Simplified Waste Classification

| Wash Stream | Material Constituent | Chemical Composition |
|---|---|---|
| 81 | 82004<br>(oxides) | 30 ($SiO_2$)<br>09 ($T_2O_2$) |
| 82A | 82004 | 30<br>09 |
| 82B | 82003 | 19-19 ($FeSO_4$) |
| 82C | 82003 | 19-27 (non chloride) |
| 52 | 82004<br>(oxides) | 18 (manganese)<br>19 (iron) |
| | 82006<br>(carbon) | |

## TABLE I

## WASTE GENERATION IN THE MANUFACTURE OF INORGANIC PIGMENTS

## $TiO_2$, $BaSO_4$, and ZnO

| Pigment | Process | Type of Waste | Process Origin |
|---|---|---|---|
| $TiO_2$ | Sulfate | • Mud - $SiO_2$, $TiO_2$ (Trace) and other inerts | Ore digestion and clarifier thickening |
| | | • Copperas ($FeSO_4$) | Centrifuging |
| | | • Ore mud + filter aid | Filtration |
| | | • $TiO_2$ fines - slurry | Filter wash waters |
| | Chloride | • $FeCl_2$, $FeCl_3$ | Centrifuging from liquid $TiCl_4$ |
| | | • Sludge - Ti rich | Centrifuging |
| $BaSO_4$ | Baryte Ore | • Wet filter cake of ore impurities | |
| ZnO | American direct | • Clinker of MnO, FeO, $MnO_2$, $Fe_2O_3$, $Fe_3O_4$, and coal | Furnace residue |

Industry No. 2819 - Miscellaneous Inorganic Chemicals

## Industry Characteristics

Waste generated in the production of HF and a number of compounds of aluminum, ammonia, magnesium, phosphorous, potassium, sodium, and sulfur are summarized in Table I.

Red mud is usually pumped to large diked lagoons for disposal. Methods for processing the mud for generation of metallurgical alumina, production of titanium, manufacture of brick, recovery of iron, etc., appear in the literature periodically, but the possibilities for commercialization seem to be remote. (237),(238)

Most of the other wastes listed in Table I would go to landfill. The calcium silicate slag formed in the production of phosphorous in the blast furnace finds some application in glass manufacture, liming of soil, and roadbed ballast.

## Simplified Waste Classification

| Wash Stream | Material Constituents | Chemical Composition |
|---|---|---|
| 81A | 82004<br>(oxides) | 19 (iron)<br>30 (silica)<br>09 (titanium)<br>29 (aluminum) |
| 12 | 12101 | |
| | 82004 | 29 |
| 82A | 51004 | |
| | 51006 | |
| | 82003 | 41-14 ($NH_4NO_3$) |
| 82B | 82003 | 06-06 ($GaCO_3$) |
| 52 | 82003 | 06-24 (calcium silicate) |
| 82C | 82004 | 30<br>19 |
| | 82003 | 29-26 (aluminim phosphate) |
| 82D | 82003 | 02-27 (NaCl) |
| | Etc. | |

## TABLE I

## WASTE GENERATION IN MISCELLANEOUS INORGANIC CHEMICAL MANUFACTURING PROCESSES

| Compound Manufactured | Type of Waste | Process Origin |
|---|---|---|
| $Al_2O_3$ | Red mud - $Fe_2O_3$, $SiO_2$, $TiO_2$, alumina and other inerts | Digestion or Bauxite (Bayer Process) |
| $AlCl_3$ | Dross | Melting of secondary aluminum ingots |
| $NH_4NO_3$ and Urea | Sludge - clay, traces of product, diatomaceous earth | Filtration |
| $MH_4Cl$ | $CaCO_3$ | Filtration (Solvay Process) |
|  | Glauber's salt ($Na_2SO_4 \cdot 10H_2O$) | By-product [$(NH_4)_2SO_4$ + NaCl] |
| $Mg(OH_2)$ | Sludge - silicaceous material and limestone | $Mg(OH_2)$ from sea water |
| Phosphoric acid | Calcium silicate slag | Blast furnace or electric furnace |
| Di- and trisodium phosphates | White mud - $SiO_2$, iron oxides and aluminum phosphate | Filter residue |
| KCl | NaCl | Wet cake |
| NaCl | $CaCO_3$, $MgCO_3$, $Mg(OH)_2$, $Fe(OH)_2$ slurry | Brine purification |

TABLE I (Continued)

| Compound Manufactured | Type of Waste | Process Origin |
|---|---|---|
| $Na_2SO_4 \cdot 10H_2O$ | Iron and aluminum oxide mud | Filtration |
| $H_2SO_4$ | Ash (small) | Burning of sulfur to $SO_2$ |
| HF | $CaSO_4$ + 1% (max) $CaF_2$ - usually slurried | $CaF_2 + H_2SO_4 \rightarrow {}_2HF + CaCO_4$ |

## Industry No. 2821 - Plastics and Synthetic Resins

### Industry Characteristics

Studies of waste generation in the plastics industry have concentrated primarily on polymeric solid wastes and effluent water streams. Organic solvent wastes are scarcely ever mentioned.

The Manufacturing Chemists Association published a report on solid waste management of plastics in 1970.(239) The EPA issued a report on industrially generated polymeric solid wastes in 1972.(240)

The three major sectors of the plastics industry are (1) resin producers, (2) processors, and (3) fabricators. Thermoplastic resins have accounted for most of the growth in the industry. The leading resin types are polyethylene (PE) - low density (LDPE) and high density (HDPE) - polypropylene (PP), polyvinyl (PVC) and polystyrene (PS). The amounts of waste product (excluding solid scrap or reclaimed polymer) generated by primary resin plants are summarized in Table I. The process origins are summarized in Table II for both resin producers and processors and fabricators.

An examination of the process flow charts for resin manufacture and effluent stream data suggest some additional types of wastes as summarized in Table III.

Waste water effluents from the manufacture of thermosetting resins (Melamine and Balelite) are discussed by Derey and Harkness.(241) Of interest in the context of this report are strong phenolic resin distillate residues (phenols, formaldehyde, alcohols, hydrocarbons and low molecular weight phenol-formaldehyde condensates) which are incinerated.

### Solid Waste Disposal

Several disposal methods have been reported for the plastic wastes generated by resin manufacturers, processors and fabricators. Data have not been obtained from a sufficiently large sample to be statistically significant, but it would appear that sanitary landfill is the principal waste disposal method. Incineration seemed to be of growing importance in 1970,(242) but stricter air pollution codes may have altered the situation. Some companies use a private landfill operated by themselves. Most companies use some sort of private or municipal service which usually trucks the wastes to landfill. Costs of disposing of waste polymer by primary resin manufacturers in 1969 have been reported as follows:

## TABLE I

## GENERATION OF POLYMERIC SOLID WASTES BY PRIMARY RESIN PRODUCERS

| Resin | 1969 Production (million tons) | % Worthless Scrap | Approximate Amount of Worthless Scrap (thousand tons) |
|---|---|---|---|
| PE | 3.3 | 0.1 - 2.8 | 33 - 57 |
| PP | 0.7 | 0.1 - 2.8 | 7 - 12 |
| PVC | 1.375 | 0.8 - 2.7 | 20 - 8 |
| PS | 0.975 | 0.26 | 2.5 - 6 |

# TABLE II

## SOURCES OF POLYMER WASTES

| Process Origin Source | Average % for Each Source | |
|---|---|---|
| | Primary Resin Producers | Processors and Fabricators |
| Off-grade product | 26 | 65 |
| Emergency dumps of reactor | 8 | - |
| Normal spillage | 22 | 19 |
| Cleanout and maintenance | 16 | 16 |
| Removal from effluent gas or liquid | 20 | - |
| Other (low melting wax, etc.) | 8 | - |

## TABLE III
## WASTE GENERATION IN PRIMARY RESIN PRODUCTION, IN ADDITION TO THE POLYMER

| Resin | Type of Waste | Process Origin |
|---|---|---|
| LDPE | Oils and Waxes | High pressure process |
| HDPE | • Still bottoms (chlorobenzene + ethylene) | |
| | • Spent catalyst (aluminum alkyl + $TiCl_4$) | |
| | • Spent catalyst ($Cr_2O_3$ or $SiO_2$; or $SiO_2$ - $Al_2O_3$) | Phillips process |
| PVC (243) | • Milky white effluent - monomers, polymers, organic and inorganic salts, organic acids, resin and rubber fine solids, wet scrubbers, catalysts, and traces of heavy metal | Emulsion, suspension and bulk polymerization processes |
| | • Sludge | Waste water treatment |
| PS | • Effluent stream (600 gal/ton of product) -<br>- Styrene - 3 ppm<br>- Benzoyl peroxide - 1400 ppm<br>- Tricalcium phosphate - 800 ppm Ca, 2200 ppm $PO_4$<br>- Alkyl aryl sulfonate<br>- Suspended solids - 500 ppm | Mass, solution or emulsion polymerization |

|  |  |
|---|---|
| PS | \$3.50/ton |
| PVC | \$2.50/ton (\$10.83 - average) |
| PE | \$2.20 - 75/ton (\$22.90 - average) |
| PP | \$2.20 - 75/ton (\$22.90 - average) |

Thermosetting polymer producers report average disposal costs of \$31.10/ton. Fabricators, who only generate from 12.5 to 250 tons/yr of polymer wastes spend an average of \$9.30/ton for disposal, with a range from \$2-25/ton.

## Solid Waste Management Alternatives

If the problem of corrosive HCl emissions from the burning of PVC wastes can be solved, incineration with heat recovery might represent the greatest potential for waste polymer reuse.

## Simplified Waste Classification

| Waste Stream | Material Constituents | Chemical Composition |
|---|---|---|
| 20 | | |
| 87A | 81008<br>81005 | 07 (chlorobenzene)<br>13 (ethylene) |
| 85 | 81017<br>81003 | 16 (aluminum alklyl)<br>09-27 (titanium chloride) |
| 31 | 82 | 30<br>29 |
| 83A | 81008<br>21003<br>82003<br>81001 | 39 (vinyl-chloride) |
| 83B | 81005<br>82003<br>83013 | 06-26 (calcium phosphate) |

Group No. 283 - Drugs

## Solid Waste Generation and Disposal

Thousands of drugs are manufactured by the pharmaceutical industry, normally by fairly complicated processes, and only the most general descriptions of the types of wastes produced are to be found in the literature. A generic list of pharmaceutical processing wastes, compiled by Booz-Allen(244) is given in Table I.

The handling of aqueous effluents in the drug industry is discussed in References (245),(247).

## Simplified Waste Classification

| Waste Stream | Material Constituents | Chemical Composition |
|---|---|---|
| 61 (dead animals) | | |
| 62 (animal remains) | | |
| 70 | | |
| 87 | | |
| 82 | 82003<br>82004<br>83011<br>51006 | 06-06<br>30 ($SiO_2$) |
| 66 | | |
| 84 | | |
| 10 | | |

## TABLE I

## PROCESSING WASTES IN THE PHARMACEUTICAL INDUSTRY NO. 283

| Type of Waste | Process Origin | Typical Disposal Modes |
|---|---|---|
| Biological Tissue | ● Manufacture of medicinal chemicals<br>● Laboratory animals | Incineration |
| Botanical Residues<br>- Bark<br>- Leaves<br>- Stems<br>- Pulp | ● Manufacture of botanical drugs and herbs | |
| Waste Chemicals<br>- Solvents<br>- Still bottoms<br>- Many others | | Reclaimed |
| Off-Quality Products | | Ground up and hauled to landfill |
| ● Fermentation Solids Filteraid; diatomaceous earth; kieselguhr; $CaCO_3$; $SiO_2$; mostly $CaSiO_3$); andmmyceliun (bacterial and fungal solids) | ● Manufacture of antibiotics and steroids | Landfill or sewer |
| ● Fermentation | | Biological treatment as feed, after drying irrigation |
| Acid and Alkali Sludges | | |
| Sewage Sludge | | |
| Radioactive Wastes | | Washings to storage tanks for decay and product rejects to AEC disposal service |
| Dusts | | Collected in bay houses filters |
| Syringes and Needles | | Destroyed and taken to landfill |

## Group No. 286 - Industrial Organic Chemicals

### Industry Characteristics

The basic raw materials for manufacture of organic chemicals are coal and petroleum. The early development of the industry was based on coal, but since WW-II, petroleum-based chemicals have been in the ascendancy. By and large, there is very little solid waste associated with the production of primary organic chemicals during the petroleum refining process, while coal chemical production does generate significant solid waste quantities. For example, the production of toluene, benzene, and xylene by catalytic reforming (hydroforming) of petroleum produces virtually no solid waste, although there is a wastewater effluent that contains aromatics and diethylene glycol.(248) Production of the same chemicals by fractional distillation of coal tar light oils generates a thick, black oily acid sludge and a tarry distillation residue, neither of which is easy to reclaim or to dispose of safely.

Most organic chemicals are of course not obtained directly from the refining of petroleum, but rather by conversion of petroleum derived raw materials. The conversion or synthesis processes produce the organic sludges and tars which tax disposal facilities of all kinds, and which can be considered hazardous if not properly handled. A number of representative chemical syntheses are cited in Table I to give a general indication of the types of wastes that must be handled. Further, examples and details may be found in other references (244)-(248). It is clear that the hazard potential of the wastes generated is enormous. Furthermore, landfill or incineration sites handling a variety of wastes for the organic chemical industry, must not only be aware of the composition and properties of individual wastes as delivered, but also of the many possibilities for deleterious interactions if the wastes should become mixed.

### Simplified Waste Classification

Typical waste streams include:

| | |
|---|---|
| 89 | solid organics |
| 85 | mixed organics and inorganics |
| 82 | inorganic solids |
| 88 | organics in aqueous streams |
| 81 | inorganic sludges, slurries, etc. |
| 84 | wet cakes containing organics and inorganics |
| 87 | organic liquids |

The chemical composition of these waste streams is highly variable and must be known for proper waste handling and disposal.

## TABLE I

## WASTE GENERATION IN THE PRODUCTION OF INDUSTRIAL ORGANIC CHEMICALS

| Chemical | Production Process | Types of Wastes | Process Origin | Disposal |
|---|---|---|---|---|
| Phenol | Chlorobenzene | Diphenyl oxide<br>Phenol and phenoy contaminated brines | Still residue | Sold |
|  | Benzene Sulfonate | Benezene | Distillation residue |  |
|  |  | $Na_2SO_3$<br>$Na_2SO_4$ | crystallized out of solution | Sold, if plant is close to a paper mill |
|  | Raschig | Tar - high boiling organics | Distillation residue |  |
| Phthalic Anhydride | Oxidation of o-xylene | Tar - brittle at room temperature | Distillation residue |  |
| Nitro-benzene | Nitration of benzene with $HNO_3$-$H_2SO_4$ mixture | Tar - dinitrobenzene and nitrophenol<br>Effluent - benzene and nitrobenzene | Steam strippings and water washings |  |
| Aniline |  | Tar | Final distillation |  |
|  |  | $Fe_3O_4$ sludge | Main reaction by-product | Sometimes sold to steel mills |
| Ethyl chloride | Ethylene gas + anhydrous HCl | Aluminum chloride | Spent catalyst |  |
|  |  | Ethylene polymers | Separation |  |
|  |  | High boiling organics | Fractionation residue |  |
| Chloral | Chlorination of ethanol | $CaSO_4$ sludge | Removal of traces of $H_2SO_4$ used |  |

TABLE I (Continued)

| Chemical | Production Process | Types of Wastes | Process Origin | Disposal |
|---|---|---|---|---|
| Citric acid | Fermentation | Mycelium filter cake | Filtration of fermentation mixture | |
| | | $CaSO_4$ filter cake | Acidulation of Ca citrate | |
| | | Spent carbon | Purification of product | Sometimes reactivated and reused |
| Coal tar fraction distilled below 150°C | Distilled | Sulfuric acid effluent with sulfonated non-aromatics and thiophenes | Washing | |
| | | $CS_2$ and cyclo-pentadiene | Benzol fore-runnings | Incineration |
| 200-250°C Coal tar fraction | Distillation | Lime mud with toxic tar acids | Regeneration of alkali | |
| Alkyl benzene | Catalytic reaction of olefins and benzene | Tars - polyalkylated benzenes and polyolefins | Condensation | |
| | | Caustic effluents - $Na_2SO_4$, NaCl, $AlCl_3$, and organic products and by-products | Product neutralization | |
| Cyclohexane | Hydrogenion of benzene | Pt with a lithium or nickel salt supported on $Al_2O_3$ | | |
| Isocyanates | Amines + phosgene | Distillation residue - carbonyl chlorides and ureas, some polymeric | Fractional distillation | Incineration |

TABLE I (Continued)

| Chemical | Production Process | Types of Wastes | Process Origin | Disposal |
|---|---|---|---|---|
| Styrene | Dehydrogenation | Tars and polymers | Still bottoms | |
| | | Effluent contaminated with benzene, toluene, styrene, ethyl benzene, formaldehyde, benzaldehyde, peroxides, etc. | Condensed stream | |
| Vinyl chloride | Acetylene | Carbon saturated with chlorine | Reaction chamber | |
| | | Spent catalyst - $Hg^{+2}$, Th, Ce, Cd, and K chlorides | Reaction chamber | |
| | Dehydrogenation | Chlorinated tars | | |
| Trichloroethylene | Thermal dehydrochlorination | Spent catalyst ($BaCl_2$ on carbon) contaminated with chlorinated tars | Reaction chamber | |
| | | Chlorinated tars | Purification | |
| Methanol | Oxidation of methane | Effluent - oils, Cr, Zn, organic chlorides, phosphates | | |

## Group No. 287 - Agricultural Chemicals

### Industry Characteristics

The air, water, and solid waste problems associated with the manufacture, use and disposal of fertilizers, pesticides, fungicides and herbicides are well recognized. Most studies have concentrated on effluent control in production plants.(249)-(250) One study by Monsanto(251) considered the totality of liquid, gaseous, and solid waste products generated in the manufacture of ethyl and methyl parathion (o-diethyl-p-nitrophenyl thiophosphate). "Semi-solid residues," which are not described in further detail in the paper are incinerated in a unit designed for complete combustion, with recovery of 99.9% of the $P_2O_5$. The liquid effluent stream was acid and contained small amounts of raw materials, alcohol, phosphorous, sulfur, chloride, soda ash, acetone, xylene, p-nitrophenol, intermediate products, and parathion. During neutralization, the stream turns bright yellow due to the p-nitrophenol, which provides a good monitor of the effectiveness of the biological treatment facilities installed.

### Waste Management Practice

### Handling, Transporation and Delivery

Solid processing wastes are stored in a variety of bins, fiber drums, tanks, dumpsters, and railroad cars or may be piled up on the ground. Dump trucks, tank trucks, railroad cars, and barges are used to transport the waste from storage to disposal. Some wastes are carried directly to the disposal area by pipeline. Some tars may be transported in heated tanks.

### Disposal

The common disposal methods for chemical processing wastes are landfill, incineration, settling in lagoons and ponds, and ocean dumping.

Several of the larger chemical companies have developed exceedingly sophisticated and beautifully engineered incineration systems to handle some of the more difficult and potentially hazardous wastes, such as tars, sludges, solvents, and chemicals, which result from chemical synthesis. The Dow System is probably one of the finest in the county.(252)-(254) Similarly, Farbenfabriken Bayer(255)-(257) and BASF(258) in Germany, and DuPont in the U.S. (ASME) have taken a comprehensive systems approach to the entire problem of solid waste management. Where it is feasible, incineration has generally been found to be a fairly attractive disposal method for the more troublesome chemical wastes, particularly those with toxic properties.(259)-(263)

Industry No. 2911 - Petroleum Refining

## Industry Characteristics

The industry is engaged primarily in the distillation, fractionation, and cracking of crude petroleum to produce gasoline, kerosene, fuel oils, lubricants, and other products. The end product in some refineries is coke; in others it is asphalt.

As indicated in Table I, 32% of U.S. refineries are located in the West South Central Region in Texas, Oklahoma, Louisiana, and Arkansas.

## Waste Generation

A summary of the liquid and solid wastes generated in the petroleum refining process is given in Table II. The solid and liquid waste problems are very closely tied together, since oil-water separation is the primary refinery water treatment operation. The API, or gravity-type separators generally used separate free oil as an emulsion from refinery wastewaters, and coincidentally collect suspended solids as a bottom sediment or sludge. The oil emulsion can be broken and the oil recycled to the refinery; the sludge must be handled as a solid waste; the relatively oil-free water which may contain ammonia, phenolics, mercaptans, sulfites, hydrocarbons, and miscellaneous organics must usually undergo additional treatment.

## Waste Management Practice

Many descriptions of water-oil-solids waste management systems as used in various refinery installations have been described in the literature.(270)-(276) Solid wastes have traditionally been sent to landfill, and relatively inert oil-free solids such as spent cracking catalyst ($SiO_2$-$Al_2O_3$) will probably continue to be disposed of in this way. Copper containing polymerization catalysts are amenable to copper recovery. Copper-containing clays are not, and copper chloride can be leached from them in a landfill. Waste treatment sludges can be used as limestone fertilizer and soil conditioners, but the market is small.(273) Oil sludges are difficult to handle in landfill, and incineration is being investigated as a possible alternative. American Oil has installed a fluid bed incinerator as part of its Mandan, North Dakota refinery complex, which will accept both oily sludge and spent caustics. Odoriferous hydrocarbons are burned, and a relatively inert solid, mainly $Na_2CO_3$ and $Na_2SO_4$, remains as a solid waste which is suitable for landfill.(277)

Burroughs Wellcome, a manufacturer of pharmaceuticals, generates quantities of waste liquids, including acetone, benzene, alcohol, ether, methyl chloride, toluene, and hexane. When they were located near New York City, they had no trouble in selling the drummed wastes liquids to converters. When they moved to Greenville, N.C., they found no markets for these liquids, and they were forced to resort to a minimal discharge pyrolysis-oxidation system to dispose of the wastes.(264)

The technical problems of achieving efficient incineration of chemical wastes are far from trivial,(265) particularly if they have the consistency of peanut butter, are tarry, or tend to clog inlet nozzles. The need to insure low level emissions to the atmosphere further complicates the design.

In 1967, chemical processing wastes in the U.S. could be broken down into the following categories:

| | |
|---|---|
| Noncombustible solids | 8,404,000 tons/yr |
| Combustible solids | 573,000 |
| Noncombustible containers | 64,000 |
| Combustible containers | 168,000 |
| Fly ash | 1,567,000 |
| Other | 466,000 |

The largest fraction of the waste (7170) was disposed of by landfill on company property.

Safe landfill of chemical wastes, organic liquids in particular, requires considerable knowledge and expertise. There have been a number of accidents in the Class 1 disposal sites in California, which can accept all types of liquid, solid, toxic chemical, and organic wastes. Explosions have occurred during compaction; toxic chemicals have caused illness in sanitation workers; and noxious, smoky fires have broken out.(266) While safety equipment at the site can help to protect operating personnel, it is vitally important to know what wastes are being delivered and what their properties are with respect to suitability for landfill disposal.

Deep well disposal(267)-(268) and deep-ocean dumping(269) are under increasing scrutiny as viable disposal methods for chemical wastes.

## TABLE I

## GEOGRAPHIC DISTRIBUTION AND EMPLOYMENT IN THE REFINING INDUSTRY No. 2911

| Geographic Area | No. of Establishments | No. of Employees (1000) |
|---|---|---|
| U.S., total | 437 | 106.7 |
| Middle Atlantic | 49 | 72.5 |
| Pennsylvania | | |
| New Jersey | | |
| New York | | |
| East North Central | 66 | 18.2 |
| Ohio | | |
| Indiana | | |
| Illinois | | |
| Michigan | | |
| Wisconsin | | |
| West North Central | 29 | 5.2 |
| Kansas | | |
| Minnesota | | |
| Missouri | | |
| N. Dakota | | |
| South Atlantic | 20 | 1.7 |
| Delaware | | |
| Maryland | | |
| Virginia | | |
| W. Virginia | | |
| East South Central | 18 | 1.8 |
| Mississippi | | |
| Alabama | | |
| Kentucky | | |
| Tennessee | | |

TABLE I (Continued)

| Geographic Area | No. of Establishments | No. of Employees (1000) |
|---|---|---|
| West South Central | 140 | 45.6 |
| Texas | | |
| Oklahoma | | |
| Louisiana | | |
| Arkansas | | |
| Mountains | 39 | 4.2 |
| Montana | | |
| Wyoming | | |
| Colorado | | |
| N. Mexico | | |
| Utah | | |
| Pacific | 66 | 15.2 |
| California | | |
| Washington | | |
| Hawaii | | |

## TABLE II

## PROCESS WASTES GENERATED IN PETROLEUM REFINING

| Liquid Wastes | Solid Wastes |
|---|---|
| Oily process waters | Separator sludge |
| Spent caustics, containing sulfides, mercaptides, phenolates, napthenate, etc. | |
| Spent alkyl acids ($H_2SO_4$) | Sulfuric acid sludge |
| Foul or sour waters - close to neutral pH; contain $H_2S$, $NH_3$, mercaptans, phenolics, and small amounts of organic acid, nitrogen bases, and cyanide | Water treatment sludge |
| Phenol-bearing wastes | |
| | Crude oil storage tank bottom sediments |
| | Dry, oil sludges - spent contact clays; filter solids, bauxite |
| | Spent reforming or hydrogenation catalysts |
| | Spent crushing catalyst |
| | Flyash |

A study of solid waste management in petroleum refining was carried out by Humble Oil,(278) and a brief summary of waste problems in the industry was prepared by Booz-Allen.(279)

Simplified Waste Classification

| Waste Stream | Material Constituents | Chemical Composition |
|---|---|---|
| 88 | | |
| 83A | 82005 (sulfide) | |
| | 81016 (mercaptans) | |
| | 81013 (phenols) | |
| | 81003 (aromatics) | 07 (naphthalene) |
| 83B | 82001 | 07 ($H_2S$) |
| | 82002 | 06 ($NH_3$) |
| | 81016 | |
| | 81013 | |
| | 82003 | 00-09 (cyanides) |
| 84 | | |
| 87 | | |
| 82 | 51004 | |
| | 82004 | 29 ($Al_2O_3$) |
| | 51006 | |
| 51 | | |
| fly ash | | |

## Industry No 3011 - Tires and Inner Tubes

### Industry Characteristics

Establishments in the 3011 industry are engaged primarily in the manufacture of pneumatic casings (rubber tires), inner tubes, solid and cushion tires of all kinds, and materials for tire repair and retreading. As indicated in Table I, there were 182 establishments in the U.S. at the time of the 1967 Census of Manufacturers employing a total of 92,700 people. Twenty-six percent of the plants and 47% of the employees were located in the East North Central Region in Ohio, Illinois, Indiana, Michigan and Wisconsin.

A schematic diagram of the tire manufacturing process is shown in Figure I.(280)-(281)

The compounding of rubber is a fine art and typically involves the blending of the following types of materials:

- Rubber
- Vulcanizing agents - S, SCl, Se, Ti, thiuram disulfides, p-quinone dioximes, polysulfides
- Accelerators - ZnO, stearic acid, litharge, MgO, amines, amine soaps
- Retarders - salicylic acid, benzoic acid, phthalic anhydride
- Age Resistors or Antioxidants - N-phenyl-2 napththylamine, alkylated diphenyl amine
- Pigments - Carbon black, ZnO, clays, $CaCO_3$, $TiO_2$
- Softeners and Extenders - petroleum oils, pine tars and resins, coal tar fractions
- Petroleum waxes
- Plasticizers - thiols
- Peptizers - thiophenols

On the "calendar" machine rubber compound is rolled into fabric, and tire cords (cotton, rayon, nylon or polyester) are arranged in parallel and bound together by the rubber. Tread stock is prepared by extrusion of a rubber compound. The bead stock is made by embedding wire cables in a tough hard rubber. The cords, beads, and tread then go into building up the tire as a cylinder on a rotating drum. The cylinder is finally molded into a doughnut and cured to form the final product.

# TABLE I

## GEOGRAPHIC DISTRIBUTION AND EMPLOYMENT OF TIRE MANUFACTURING ESTABLISHMENTS, INDUSTRY NO. 3011

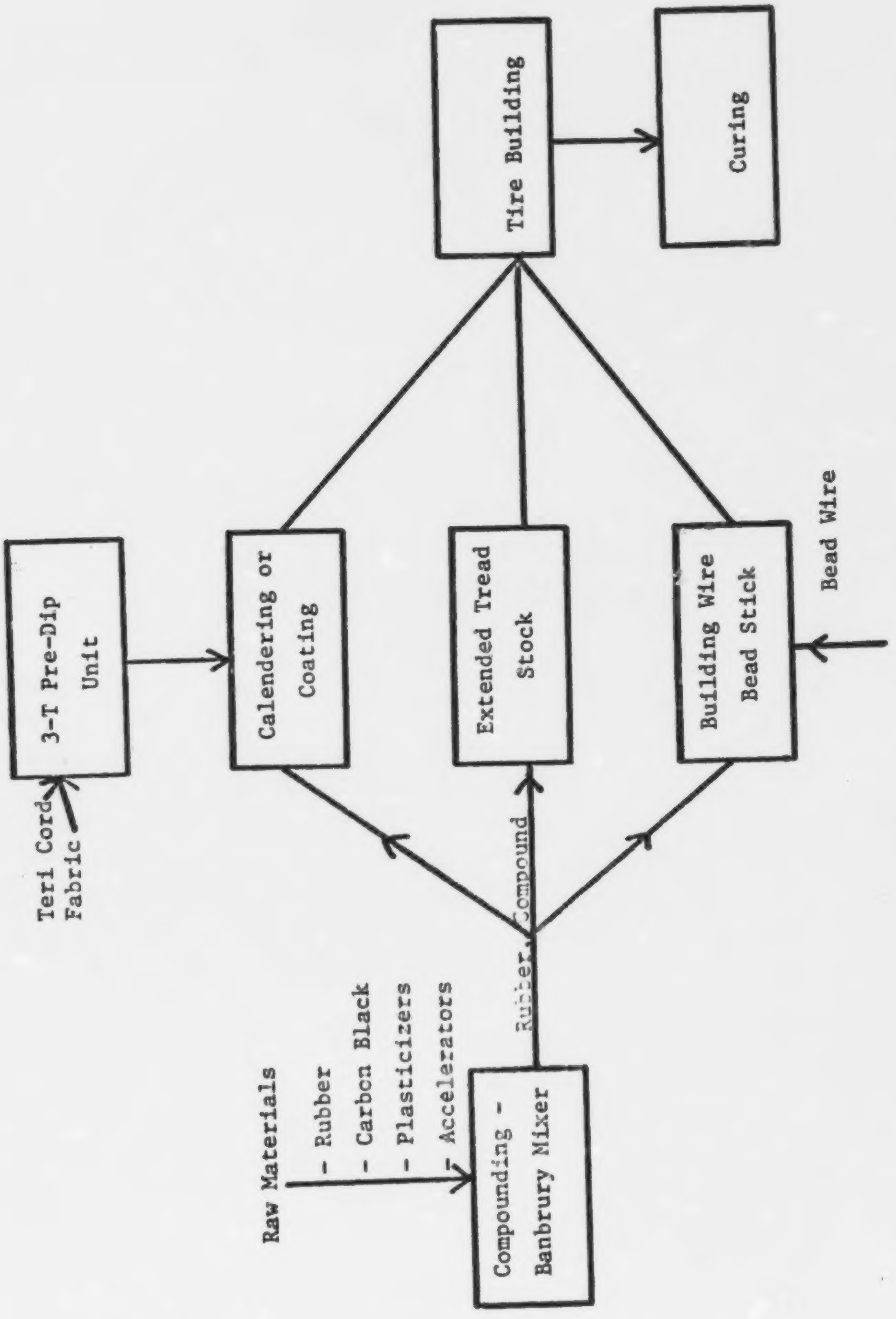
| Geographic Area | No. of Establishments | No. of Employees (1000) |
|---|---|---|
| U.S., total | 182 | 92.7 |
| New England | 8 | > 2.5 |
| Massachusetts | | |
| Connecticut | | |
| Middle Atlantic | 19 | > 2.5 |
| Pennsylvania | | |
| New York | | |
| East North Central | 47 | 42.7 |
| Ohio | | |
| Illinois | | |
| Indiana | | |
| Michigan | | |
| Wisconsin | | |
| West North Central | 13 | 7.5 |
| Iowa | | |
| Mississippi | | |
| Kansas | | |
| South Atlantic | 20 | 7.5 |
| Georgia | | |
| North Carolina | | |
| Virginia | | |
| Maryland | | |
| East South Central | 19 | 12.1 |
| Alabama | | |
| Tennessee | | |
| Mississippi | | |
| Kentucky | | |

TABLE I (Continued)

| Geographic Area | No. of Establishments | No. of Employees (1000) |
|---|---|---|
| West South Central | 22 | 5.7 |
| Texas | | |
| Arkansas | | |
| Oklahoma | | |
| Mountain | 1 | 1.0 - 2.499 |
| Colorado | | |
| Pacific | 33 | > 2.5 |
| California | | |

FIGURE I

SCHEMATIC DIAGRAM OF THE TIRE MANUFACTURING PROCESS


Raw Materials
- Rubber
- Carbon Black
- Plasticizers
- Accelerators
Compounding - Banbrury Mixer
Rubber Compound
Teri Cord Fabric
3-T Pre-Dip Unit
Calendering or Coating
Extended Tread Stock
Building Wire Bead Stick
Bead Wire
Tire Building
Curing

## Solid Waste Generation

In a 1969 study by Combustion Engineering of waste generation in SIC industries 3011 and 306 (Miscellaneous fabricated rubber products), the processing wastes were classified into two types as follows:

(1) Rubber and rubber trimmings - rubber, fabric, bead metal
(2) Solvents and pigments

29% oil and grease
47% solvents
25% cements, latex, etc.

In a more extensive study by Uniroyal in 1971, wastes which are physically solid were characterized in greater depth, but no information was collected with respect to waste solvents. In the manufacture of tires, however, solvent wastes should be minimal. The pre-dipping of tire cords is done in an aqueous emulsion, and solvents, primarily toluene, hexane, or ketones are only used in the repair area.

The types and quantities of true solid wastes generated in the manufacture of tire and tire products are summarized in Table II.(282)

## Solid Waste Management Practice

The industry appears to practice very little segregation, which virtually precludes incineration as a disposal means. Rubber wastes have a high BTU content and except at very high temperatures, produce obnoxious smokey flames, high in acid and sulfurous fumes, which could not meet air quality standards. For the most part, then, the total mixed wastes from the tire and inner tube industries are manually handled and hauled by truck to dumps or sanitary landfills. The wastes may or may not be compressed and baled. The ultimate disposal site may be owned privately or by the municipality. Costs of waste disposal, as summarized in the Uniroyal study,(282) fall into a rather broad range as follows:

| | Cost/ton (range) | Cost/ton (average) |
|---|---|---|
| In-Plant Collection | \$4 - 27 | \$16 (17 sites) |
| Carting and Dump | \$4 - 20 | \$11 (17 sites) |
| Total | \$3 - 45 | \$24 (21 sites) |

In-plant collection figures include direct labor, supervision, and overhead for collecting wastes from operator's receptables and delivering to a common pick-up point. Carting and dumping costs are for the most part contractor's fees.

## TABLE II

## SOLID WASTE GENERATED IN TIRE AND TIRE PRODUCTS PRODUCTION, 1968

| Type of Waste | Quantity (million lbs/yr) | Price Origin |
|---|---|---|
| 1. Paper, cardboard and wood<br>• Paper bags contaminated with raw materials (carbon black, mineral pigments, chemicals)<br>• Separator paper<br>• Other packaging<br>• Card and paper stock used to identify and control in-process materials | 100.5 | Raw materials input |
| 2. Rubber compound<br>• Combination of elastomers, oils, pigments, and other chemicals (usually unvulcanized)<br>• In-process trimmings<br>• Molding wastes<br>• In-process spoiled stock<br>• Quality rejects<br>• Experimental and test products | 82 | Compounding<br>Extrusion of tread<br>Bead stock preparation<br>Molding and Curing<br>Quality control and testing |
| 3. Curing Bags - 12 lb tire-like structures of rubber and fabric used to exert internal pressure during curing | 7 - 8 | Curing |

TABLE II (Continued)

| Type of Waste | Quantity (million lbs/yr) | Price Origin |
|---|---|---|
| 4. Textile Materials<br>• Textile fabric<br>• Tire cord<br>• Textile content of uncured tire carcass scrap<br>• Textile content of rejected finished goods | 44.2 | Calendering<br>Bead stock preparation<br>Tire building<br>Quality control and testing |
| 5. Metal - high carbon steel wire of tire bead<br>• Defective material<br>• Trimmings<br>• In-process waste<br>• Metal content of rejected finished goods | 72.7 | Bead stock preparation<br>Extrusion of tread<br>Tire building<br>Quality control and testing |
| 6. Other Materials<br>• Floor sweepings<br>• Cafeteria wastes<br>• Office wastes<br>• Polyethylene separators used to keep layers of rubber compound from sticking | 105.2 | Rubber compound preparation<br>Calendering<br>Cafeteria<br>Offices<br>Maintenance |

## Solid Waste Management Alternatives

The wastes reported in the foregoing discussion are true wastes. In addition, the industry does generate some salable scrap. Some in-process waste is reused in the plant or as raw material for low quality goods. Some curing bags are handled by reclaimers, but only with difficulty, and therefore the market is small. Unvulcanized textile fabric and tire cord scrap can be readily sold. There is also a market for tire carcass scrap which is 60% rubber compound and 40% textile; it is used by the mechanical rubber goods industry. There was a time when scrap bead wire was compressed, baled, and sold to the steel industry, but it tends to be too bulky for the blast furnace, and it is not at all suitable for the BOF process.

There is a great deal of interest in reducing the quantity of rubber wastes generated at the source. Quality rejects in tire production run around 1% of production. Direct process wastes (rubber compound, fabric, and metal) amount to about 3% of the weight of finished products.

If the solid wastes were segregated, at least into rubber and non-rubber portions, the latter could be incinerated, with a reduction of the volume of waste being disposed of in landfill.(283) The development of pollution-free incinerators for the burning of rubber wastes, would be highly desirable, particularly if the heat could be utilized to generate low pressure steam for the processing operations.(282)

Combustion Engineering reported that three of the eleven plants they visited did practice some degree of incineration. One establishment burned a major portion of their wastes in the municipal incinerator. A second incinerated 17% of its total waste, primarily paper, lumber, etc. A third plant incinerated 3% of its waste for the specific purpose of reclaiming the metal in fabricated items. Goodyear Tire and Rubber Co. has installed a vortex-type liquid waste incinerator at their Danville, Va. plant to burn processing wastes with characteristics similar to No. 6 oil.(284)

There have been many more or less academic rubber reuse and recycling studies,(285)-(291) largely unproven from the point of view of economics.

## Simplified Waste Classification

| Waste Stream | Material Constituents | Chemical Composition |
|---|---|---|
| 95 | | |
| 20 | 21001<br>23000 | |
| 40 | | |
| 13 | 11213 | |
| 92 | | |
| 91 | | |

## Industry No. 3111 - Leather Tanning and Finishing

### Industry Characteristics

As indicated in Table I, there were at the time of the 1967 Census of Manufacturers, 519 leather tanning and finishing establishments in the U.S., employing a total of 30,700 people. Both the number of establishments and the employment are probably declining. According to the data of Table I, the highest percentage of tanneries are located in New England and the Middle Atlantic States, with another relatively high concentration in the Milwaukee-Chicago area.

Virtually all tanneries today, with very few exceptions, use the chrome tanning process, as shown schematically in Figure 1. Hides are normally received in the green-salted condition. They are salted at the slaughterhouse, stacked, and tied with twine for shipment. All operations up to and including the chrome tan step might typically be done in a single cylindrical rotating mill, 10 feet long and 10 feet in diameter. The mill is loaded with about 900 lbs. of hides, and the required solutions for each operation are added successfully and drained out when that operation is completed.

As indicated, the hides are washed and soaked to remove blood, dirt, dung and free salt and to soften the hide. Muscle and fatty tissues are removed mechanically in the fleshing operation, if necessary. In modern practice, the green-salted hides have already been fleshed. For the liming operation, a suspension of lime hydrate and alkaline reducing agents, such as $Na_2S$ or amines as accelerators, is introduced to loosen the hair and epidermis and to remove grease. In "bating," a solution of a proteolytic enzyme (pancreatin or trypsin) and an acid salt (e.g., $[NH_4]_2SO_4$) are introduced to remove adsorbed lime and to hydrolize undesirable proteins. Pickling involves a soak in 0.75% $H_2SO_4$ and 5-8% NaCl to bring the hides to the acid condition necessary for absorption of chromium. Finally, the chrome tanning solution, typically a basic chromic sulfate or chromic chloride, is added. The wastes from the processes described up to this point are net alkaline. The coloring and fatliquoring are done in acid solutions. A separate mill is typically used and the waste stream is kept apart from the alkaline tanning wastes.

In the finishing operation, skins are dried, cut to uniform size ("splitting"), and "scraped" (surface shaved off). The skins are then pasted onto a porcelain plate and dried in an oven. The final product goes to a "sander" and is ready for sale.

The tanning process uses 5 gallons of water per pound of green salted pigskin and 8 gallons per pound of cowhide.

## Solid Waste Generation and Disposal

Most studies of the tanning industry have been concerned with waste water effluent.(292)-(302) This effluent will increasingly require pretreatment for removal of chromium in order to meet water quality standards for effluent discharges. Most of the chromium is likely to end up in an alkaline sludge which will require land disposal. While it is recognized that the sludge must be maintained at a pH above 8.5 to assure retention of the chromium as a solid precipitate, it is not entirely clear that the necessary alkaline conditions will be maintained over time at even sanitary landfills.

A summary of solid waste generation and disposal at one pigskin tannery, which may or may not be typical of the industry as a whole, is given in Table II. At this particular plant, grease is dumped. In other pigskin tanneries, hides are degreased in a mixture of warm water and solvent. The resultant solution of solvent, grease, and water is pumped out to a large tank and decanted. The solvent and grease are sent to a stripping column, where the solvent is recovered for reuse and the grease is removed as a by-product.(293) In 1969, it was reported that such grease could be sold for 3.5 to 4.0 cents per pound.(299)

In the Combustion Engineering Survey,(300) tannery wastes were classified as plant trash, leather dust and shavings, wet trimmings, hair and fleshings. Dry trimmings, hair and fleshings were sold in all eleven plants visited. The ultimate disposal methods were dumping or landfill in ten establishments and incineration in one. The disposal facility was privately owned in three cases, by the municipality in seven, and by a merchant in one case. The study estimated a total solid waste output from the industry excluding recyclable or soluble scrap, of 598 million lbs/yr.

## Solid Waste Management Alternatives

Several technically feasible process for increased utilization of tannery wastes are discussed in the literature,(301)-(302) but there is little data on the economics of recovery.

## TABLE I

## GEOGRAPHIC DISTRIBUTION AND EMPLOYMENT IN THE LEATHER TANNING AND FINISHING INDUSTRY NO. 3111

| Geographic Area | Number of Establishments | No. of Employees (1000) |
|---|---|---|
| U.S. total | 519 | 30.7 |
| New England | 183 | 9.7 |
| Massachusetts | | |
| New Hampshire | | |
| Maine | | |
| Vermont | | |
| Middle Atlantic | 176 | 6.7 |
| New York | | |
| New Jersey | | |
| Pennsylvania | | |
| East North Central | 74 | 8.2 |
| Wisconsin | | |
| Illinois | | |
| Ohio | | |
| Michigan | | |
| Indiana | | |
| West North Central | 13 | 0.8 |
| Missouri | | |
| Minnesota | | |
| South Atlantic | 26 | 3.0 |
| Delaware | | |
| Virginia | | |
| West Virginia | | |
| Maryland | | |
| North Carolina | | |
| Georgia | | |

TABLE I (Continued)

| Geographic Area | Number of Establishments | No. of Employees (1000) |
|---|---|---|
| East South Central | 12 | 1.4 |
| Tennessee | | |
| Kentucky | | |
| West South Central | 9 | 0.2 |
| Texas | | |
| Pacific | 22 | 0.7 |
| California | | |

## TABLE II

## SOLID WASTE GENERATION AND DISPOSAL AT A TANNERY

### Plant Data

| | |
|---|---|
| No. of employees | 102 |
| Pounds of green salted hides processed/day | 50,000 - 60,000 |

### Waste Generation and Disposal

| Type of Waste | Quantity | Process Origin | Disposal |
|---|---|---|---|
| 1. Packaging Wastes | | | |
| • Twine | | Used to bundle hides shipped in | Landfill |
| • Large cardboard boxes | | Used for shipping frozen hides | |
| • Metal drums | | Containers for chemicals | Sold to highest bidder (@35¢/ea) |
| 2. Non-processing Wastes | | | |
| a. Office Wastes | | | Landfill |
| b. Outside Maintenance Wastes<br>• Grass clippings<br>• Tree prunings | | | Taken by a private yard man who compacts it or takes it to landfill |
| c. Construction and Demolition Debris | | | Loaded into fiber drums and hauled to landfill |
| 3. Processing Wastes | | | |
| • Leather scraps | | Splitting operation | Baled, loaded onto a truck and shipped to Milwaukee - pulverized to make fertilizer extender |

TABLE II (Continued)

| Type of Waste | Quantity | Process Origin | Disposal |
|---|---|---|---|
| • Leather shavings | | Scraping of the hide surface | Landfill - hauled by the city |
| • Leather dust | | Final sanding collected on coarse screens from tanning effluent | Landfill |
| • Grease and leather scraps | 1/2-3/4 cu yd/day | | Landfill - hauled by city |
| 6. Water Treatment Wastes | 30 cu yds/ week | Pretreatment of waste water effluent | Combined with municipal sludge and sent to landfill |
| • Sludge - 1-5% chromium | | | |

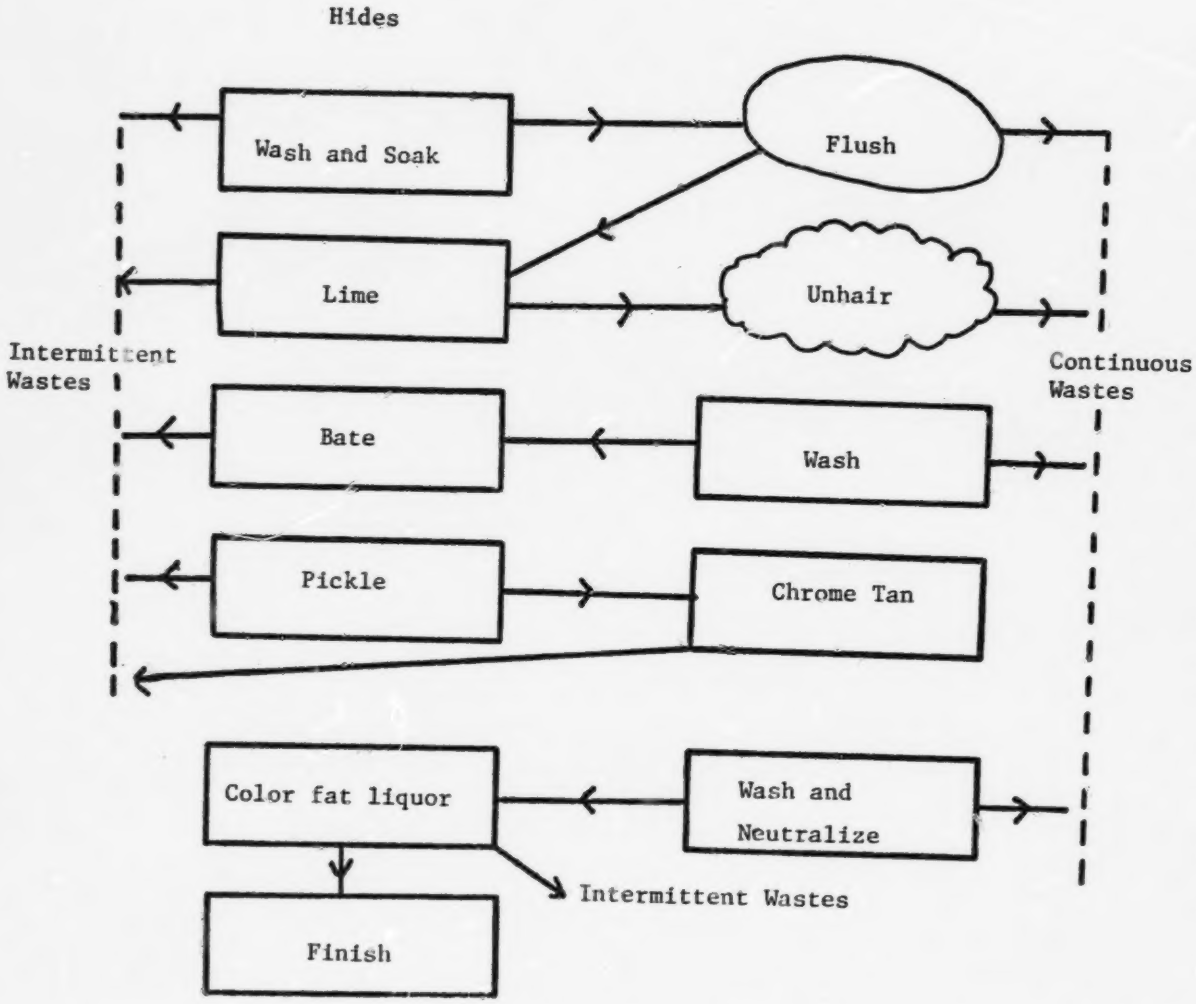

Hides
Wash and Soak
Flush
Lime
Unhair
Intermittent Wastes
Continuous Wastes
Bate
Wash
Pickle
Chrome Tan
Color fat liquor
Wash and Neutralize
Intermittent Wastes
Finish

FIGURE I

SCHEMATIC DIAGRAM OF THE CHROME TANNING PROCESS

## Simplified Waste Classification

| Waste Stream | Material Constituents | Chemical Composition |
|---|---|---|
| 80 | 82003 | 15-19 (chrome sulfate)<br>15-27 (chrome chloride)<br>02-27 (NaCl) |
| | 82004 | 06 (CaO) |
| 95 | | |
| 63 | | |
| 92 | | |
| 94 | | |
| 93 | | |
| 84 | 82004 | 06 (calcium oxide)<br>15 (chromium oxide) |
| 62 | | |

## Industry No. 3229 -- Fiberglass

Fiberglass production is an example of a mature, relatively large scale ceramic manufacturing process, dominated by such firms as Owens Corning Fiberglass Co., PPG Industries, etc. Typically a plant will produce 50 to 100 million pounds of fiberglass a year. Fiberglass operation has no serious solid waste problems per se. Very little of the solid waste is now considered to be recyclable and chances in the future are slim. Fiberglass has to be closely composition controlled and contaminated scrap is not suitable for reuse as collected. Total quantities are probably a low fraction of input weight. A summary of wastes generated is tabulated below.

| Steps | Materials Used and Remarks | Waste Generated |
|---|---|---|
| Receiving | Bulk Chemicals in Box Cars<br>Chemicals in bags and drums | Packaging Materials (bags, damaged drums)<br>Dust |
| Batch Plant (Glass) | Inorganic Chemicals $B_2O_3$, silica, kaolin, fluorspar, sodium sulfate kaolin, alumina, lithium carbonate, dolomite, soda ash | Dust Collected |
| Melting (Furnace) | Repair of Furnace Occasionally needs replacement of refractories, steel structures, etc. | Stack Dust<br>Refractory Debris<br>Scrap Iron |
| Fiber Drawings | Start up and Stop | Fiberglass ends |
| Sizing and Binders | Sprayed on organics including oils, liquid epoxies, starch, phenolics, gelatin | Fog and Dust<br>Solids and sludge from settling tanks |
| Winding (Preliminary) | Wound on cardboard tubes | Discard damaged tubes |
| Finishing Operation<br>Chopping<br>Mats<br>Twisted Yarn<br>Packaging and Shipping | | Scrap organic coated glass<br>Packaging material scrap |

Industry No. 3144 - Women's Shoes

## Industry Characteristics

Industries related to clothing, including the manufacture of women's shoes, operate under conditions somewhat different from many other industries. Because of changing fashions, they tend to be hectic, seasonal, highly competitive, and beset with constant changes in patterns, dies, etc. In the past, many of the shoe industry factories were small, and scattered in towns and small cities throughout New England and in the Philadelphia and St. Louis areas. In recent years increased labor costs and the impact of foreign competition have raised havoc in the shoe industry and the attrition rate, especially among the smaller operations, has been great. Solid waste disposal in the industry is by and large of the most primitive type and the industry cannot afford any increases in operating costs for more sophisticated disposal techniques.

## Waste Generation

In a plant making fine shoes, the majority of the solid waste is leather trimmings, largely from the cutting and sole rooms. There may also be a small amount of fabric waste and, if rubber soles are used, rubber waste. The leather trimmings are usually sold to an outside vendor. In a plant making cheap shoes, little or no genuine leather is used and the solid waste is largely plastics and synthetic fabrics, none of which are recovered.

In the past, manufacturers of lasts and heels produced a lot of wood waste, but now these items are made of plastic. Changing fashions quickly render lasts obsolete. Sometimes lasts can be restyled, but more often, despite their expense, they are thrown out.

The solid waste from a shoe factory includes bottles, cans, or drums in which solvents, sprays, and other chemical supplies are received. There is also a relatively small amount of packaging waste including crates that machinery is received in (much of the machinery is leased and is moved uncrated). Many of the operations use rags, oily rags are cleaned, reused and finally discarded. There is a small quantity of thread, string, etc. swept from the floor of the stitching room. There is also finely powdered waste collected from blowers. With the exception of the leather trimmings and the rags all of the wastes go unseparated into the trash. The trash is collected either by private collectors or the town and is carried to the town dump; in the case of small towns, it is usually an open dump. A few of the shoe-making cities, such as Lawrence, Mass., have incinerators, but even in Lawrence, open dumping and open burning continues.

Few shoe plants are large enough to have eating facilities so there is usually no cafeteria waste. The amount of office waste, largely paper, from a shoe plant is relatively small.

Simplified Waste Classification

Waste Stream

63 (leather)
45 (textiles)
20 (plastics)
95
10

## Industry No. 3211 - Flat Glass

### Industry Characteristics

The industry manufactures flat glass, including window glass, plate glass, float glass, and laminated glass. As shown in Table I, there were 64 flat glass plants employing 23,900 people in the U.S. at the time of the 1967 Census of Manufacturers. The highest concentration of plants is in the East North Central region in Illinois, Ohio and Michigan.

The principal raw materials used in flat glass manufacture are glass sand (almost pure silica), soda ash ($Na_2O$), and lime ($CaO$) or burnt limestone ($CaO \cdot MgO$ from dolomite). Other additions are typically salt cake (crude sodium sulfate), powdered coal (to reduce sulfate to sulfite), arsenic trioxide, sodium or potassium nitrates, feldspars ($R_2O \cdot Al_2O_3 \cdot 6\ SiO_2$, R = Na, K), and cullet (waste glass from rejected products or trim). In flat glass manufacture, cullet constitutes about 20-25% of the raw materials input, although the percentage may vary considerably in particular glass formulations.(303) Glass making is an art, and while some cullet is necessary to facilitate melting, its effects on the "workability" of the glass limit the amounts that the glass maker will tolerate in a melt. Three processes used in the manufacture of flat glass are shown schematically in Figure I. (304)

All types of annealed glass must undergo one or more finishing operations such as cleaning, grinding, polishing, cutting, sandblasting, grating and/or gaging.

### Solid Waste Generation and Disposal

Processing wastes from plate glass manufacture include:

- Defective batch material
- Defective product
- Trim Scrap
- Grinding and polishing abrasives (slurries)

In addition, most establishments will generate the usual plant trash, packaging wastes, sawdusts, and cardboard.(305)

The industry recycles all internally generated cullet, and in 1967 purchased 244,000 tons of additional cullet,(303) or about 10% of the raw materials input.

## TABLE I

## GEOGRAPHIC DISTRIBUTION AND EMPLOYMENT IN THE FLAT GLASS INDUSTRY NO. 3211

| Geographic Area | No. of Establishments | No. of Employees (1000) |
|---|---|---|
| U.S., Total | 64 | 23.9 |
| Middle Atlantic | 9 | >2.5 |
| Pennsylvania | | |
| East North Central | 17 | >2.5 |
| Illinois | | |
| Ohio | | |
| Michigan | | |
| West North Central | 5 | 1.0 - 2.499 |
| Missouri | | |
| South Atlantic | 9 | 3.8 |
| West Virginia | | |
| Maryland | | |
| East South Central | 3 | >2.5 |
| Tennessee | | |
| West South Central | 8 | 1.0 - 2.499 |
| Oklahoma | | |
| Arkansas | | |
| Louisiana | | |
| Pacific | 11 | 1.0 - 2.499 |
| California | | |

Both processing wastes, apart from cullet, and non-processing wastes are generally hauled by dump truck to landfill or dump, either private or municipal. However, one establishment visited by Combustion Engineering was putting processing wastes into the sewer.(305)

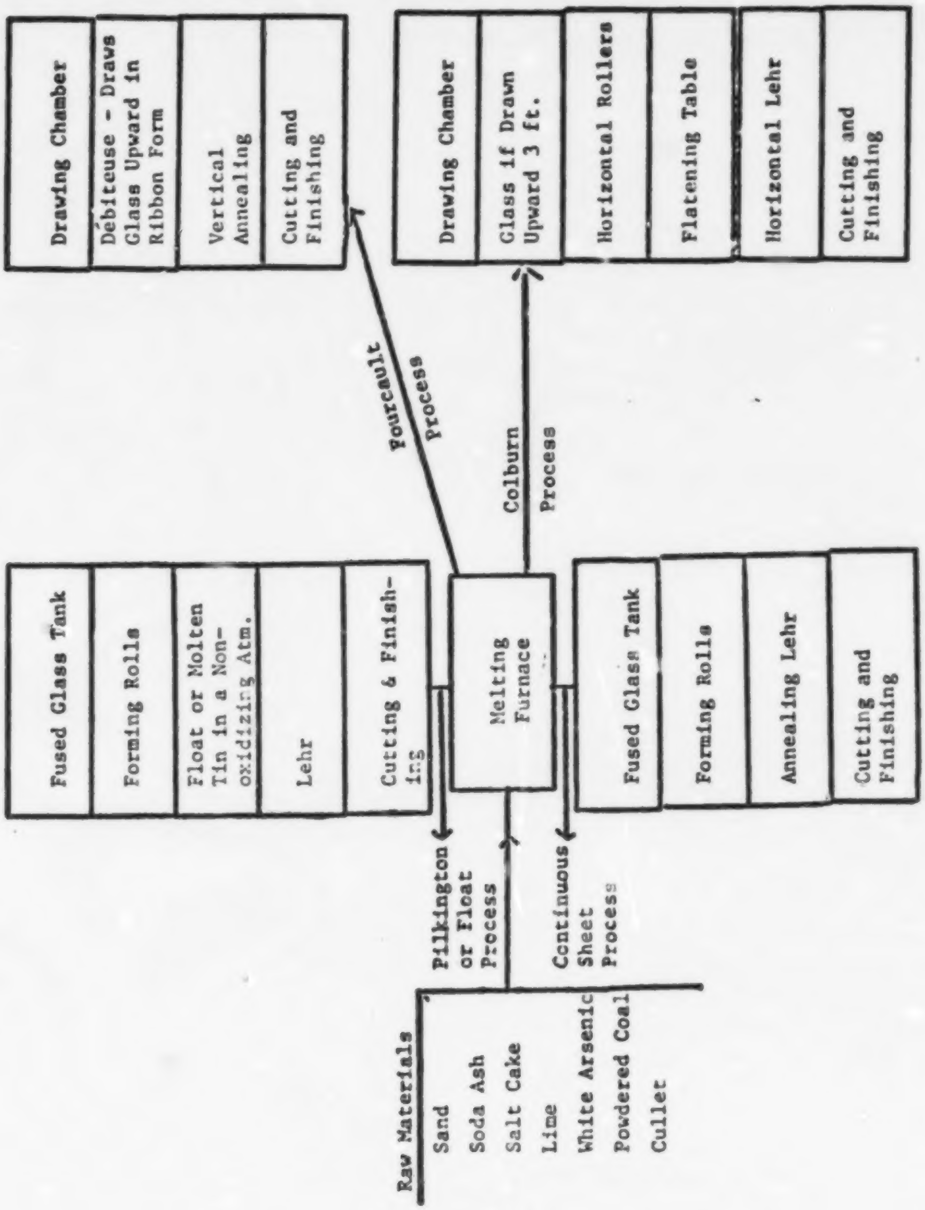
In a large glass plant, raw materials are regularly unloaded into storage silos with considerable generation of dust. Pittsburgh Plate Glass, in its Clarksburg, West Virginia plant, has installed fabric filter bag dust collectors. The filter bags are shaken down once a day into a 16-cu. ft. hopper bottom. The hoppers are emptied once a week and the dust is hauled to a sanitary landfill.(306)

## Simplified Waste Classification

| Waste Stream |
|---|
| 82 |
| 81 |

**FIGURE I**

**MANUFACTURE OF FLAT GLASS BY THE FOURCAULT, COLBURN, CONTINUOUS SHEET AND PILKINGTON PROCESSES**


Drawing Chamber
Débiteuse - Draws Glass Upward in Ribbon Form
Vertical Annealing
Cutting and Finishing
Drawing Chamber
Glass if Drawn Upward 3 ft.
Horizontal Rollers
Flatening Table
Horizontal Lehr
Cutting and Finishing
Fourcault Process
Colburn Process
Fused Glass Tank
Forming Rolls
Float or Molten Tin in a Non-oxidizing Atm.
Lehr
Cutting & Finishing
Melting Furnace
Fused Glass Tank
Forming Rolls
Annealing Lehr
Cutting and Finishing
Pilkington or Float Process
Continuous Sheet Process
Raw Materials
Sand
Soda Ash
Salt Cake
Lime
White Arsenic
Powdered Coal
Cullet

## Industry No. 3312 - Blast Furnaces (Including Coke Ovens), Steel Works and Rolling Mills

### Industry Characteristics

Iron and steel manufacturing operations are conveniently grouped as follows:

- Coke production - manufacture of metallurgical coke for pig iron production
- Pig iron manufacture - blast furnace production of hot metal, pig iron, silvery pig iron and ferroalloys from iron ore and steel scrap
- Steel making - conversion of pig iron and scrap into steel in the basic oxygen process, electric furnace or open hearth furnace
- Rolling mill operations - hot rolling of iron and steel into basic shapes such as plates, sheets, strips, rods, bars and tubing
- Finishing operations - cold reduction, tin plating, galvanizing, chrome plating, coating, tempering and polishing

In practice there are many variations on these basic operations, and generally a single mill would not carry out all of them. Geographic distribution and employment in the industry in 1967 are summarized in Table I. According to the 1967 Iron and Steel Works Directory,(303) 24 producers operate both blast and steel furnaces and are representative of the integrated steel industry, including the industry giants - U.S. Steel, Bethlehem, Republic, Armco, and National Steel. In 1963, the four largest companies produced 50%, and the eight largest 69%, of all steel products in the U.S.

Water consumption in the steel industry is among the highest for any manufacturing industry, averaging about 40,000 gal/ton of finished steel. A medium size mill might discharge 100 million gallons of water per day.(307)

### Solid Waste Generation and Disposal

Most of the literature on pollution control in the steel industry has concentrated on ambient air emissions and water effluent.(308)-(312) A brief summary of solid waste generation in the principal steel manufacturing operations has been given by Bramer.(307) His findings are as follows:

Pig Iron Manufacture - The major solid waste is slag, a mixture of silicates and aluminosilicates of lime and other bases. Table II gives the range of composition of typical slags, and the principal minerals in which the various compounds are often incorporated.

In 1971, the demand for blast furnance slag exceeded supply, and all of 24.8 million tons of slag produced in blast furnace operations was sold or used. The principal uses include aggregate for highway, airport and other types of combustion, railroad ballast, cement manufacturing, insulating materials, agricultural slag, roof covering, etc.(314) If, as reported by Bramer, "Huge slag dumps continue to build up near most steel mills," this may reflect huge backlogs from previous years. In 1950, for example, 65 million tons of pig iron were manufactured, leading to the generation of 33 million tons of slag, only two thirds of which was utilized.(315)-(347)

Additional solid waste is recovered as blast furnace flue dust, which has a typical composition of 43.70% Fe, 14.33% $SiO_2$, 2.97% CaO, 0.85% MgO, 0.14% S, 0.38% Mn, and 0.045% P. For mills which have sintering facilities, this "waste" is reusable as blast furnace burden. Otherwise it can present a serious disposal problem.

Steelmaking - The control of airborne particulate emissions through the use of venturi scrubbers, electrostatic precipitators and baghouses leads to the recovery of solids which represent a serious waste disposal problem. The material is unsuitable for reuse, largely because of its high concentration of zinc, which originates in the scrap metal charge.

Steelmaking slag amounted to 8.5 million tons in 1971,(348) of all which was sold or reused.

Rolling Mill Operations - The principal solid waste is sludge resulting from lime neutralization of spent pickle liquor. Lagoons full of this material, which is voluminous and slow-settling, present a major problem at many mills.

Large tonnages of crop ends and scale also result from rolling mill operations, but all of it can be reused within the mill or sintered for recycle.

Finishing Operations - Internally generated scrap can essentially all be reused, although tin-plated or galvanized material may first have to be reclaimed. Additional solid waste problems are associated with sludges from tank elements and precipitates from water treatments.

## TABLE I

## GEOGRAPHIC DISTRIBUTION AND EMPLOYMENT IN THE STEEL INDUSTRY NO. 3312

| Geographic Area | No. of Establishments | No. of Employees (1000) |
|---|---|---|
| U.S., total | 329 | 533.1 |
| New England | 8 | 3.1 |
| Massachusetts | | |
| Connecticut | | |
| Rhode Island | | |
| Middle Atlantic | 116 | 196.5 |
| Pennsylvania | | |
| New York | | |
| New Jersey | | |
| North Central | 104 | 217.4 |
| East North Central | 94 | >2.5 |
| Ohio | | |
| Illinois | | |
| Michigan | | |
| Indiana | | |
| Wisconsin | | |
| West North Central | 10 | >2.5 |
| Minnesota | | |
| Missouri | | |
| South | 61 | 84.1 |
| South Atlantic | 24 | >2.5 |
| Virginia | | |
| West Virginia | | |
| Maryland | | |
| Georgia | | |
| Delaware | | |
| North Carolina | | |
| South Carolina | | |
| Florida | | |

## TABLE I (Continued)

| Geographic Area | No. of Establishments | No. of Employees (1000) |
|---|---|---|
| East South Central | 28 | 29.5 |
| Alabama | | |
| Kentucky | | |
| Tennessee | | |
| Mississippi | | |
| West South Central | 9 | >2.5 |
| Texas | | |
| Oklahoma | | |
| West | 40 | 31.9 |
| Mountain | 3 | >2.5 |
| Colorado | | |
| Utah | | |
| Pacific | 37 | >2.5 |
| California | | |
| Washington | | |
| Oregon | | |
| Hawaii | | |

## TABLE II

## OXIDE, SULFUR, MINERAL COMPOSITION OF TYPICAL BLAST FURNACE SLAGS

| Slag Component | Weight |
|---|---|
| $SiO_2$ | 33-42 |
| $Al_2O_3$ | 10-16 |
| CaO | 36-45 |
| MgO | 3-17 |
| S | 1-3 |
| FeO | 0.3-2 |
| MnO | 0.2-1.5 |

| Principal Minerals in Slag | |
|---|---|
| Ahumanite | $Ca_2(M_g, Fe)\ Si_2O_7$ |
| Gehlenite | $Ca_2Al_2SiO_7$ |
| Calcium orthosilicate | $\beta \cdot 2\ CaO \cdot SiO$ |
| Pseudowollastonite | $CaO \cdot SiO_2$ |
| Monocalcium silicate | $\beta\ CaO \cdot SiO_2$ |
| Olivines | $(Mg, Fe)_2\ SiO_4$ |
| Pyroxenes | $RO \cdot SiO_2$ (R = Ca, Mg, Fe, Mn) |
| Merwinite | $Ca_3Mg(SiO_4)_2$ |
| Calcium sulfide | CaS |

In the Midland Group of the British Steel Company, 70% of the steelmaking fume and the bulk of the coarse mill scale is in fact recycled. However, if these figures are typical, there would still be 450,000 tons per year of unutilized fines generated in the United Kingdom.

Waste oil, due to loss of surface coating oils, discarding of spent rolling lubricants, and leaking hydraulic systems, is generated in surprisingly large quantities in the still industry. Armco's Middletown, Ohio facility generates several thousand gallons of waste oil per day. Armco has installed a waste treatment system with significant reclamation of the waste oil - 300-400 gal/day of hydraulic oil, 300-400 gal/day of temper mill oil, and 300-400 gal/day of cold mill oil. The extent to which reclamation is practiced at other plants is unknown.

## Secondary and Scrap Materials Utilization

Scrap materials are used extensively in both blast furnaces and steelmaking furnaces. In 1967, scrap materials represented almost 2% of the total raw materials input to the blast furnace and close to 40% of the raw materials input to steelmaking furnaces.(352) The industry distinguishes among "home scrap," which is generated within the industry, "prompt scrap," which is generated in other industries, and "obsolete scrap," which is metal derived from products in structures that have completed their useful economic life. In 1967, the steel industry consumed 52.3 million tons of home scrap, 11.7 million tons of prompt scrap, and 21.4 million tons of obsolete scrap. An additional 7.6 million tons of obsolete scrap was exported.

The economic and technical issues which determine the utilization of various types of scrap within the steel industry are extremely complicated, and have been discussed extensively in the literature. It should be pointed out that iron-bearing scrap cannot be used indiscriminately by the steel industry. The loss of "heat" due to the introduction of contaminants in scrap from unknown sources could be very costly in both time and manpower.

## Simplified Waste Classification

| Waste Stream |
|---|
| 52 |
| 82 |
| 81 |
| 84 |
| 88 |

## Industry No 8062 - General Medical and Surgical Hospitals

### Solid Waste Generation

Hospital wastes, particularly those generated in patient care, can be carriers of disease and filth, and if improperly handled, they represent potential accident and infection hazards.

The general types of wastes generated in hospitals are summarized in Table I.(358)-(359) It should be pointed out that disposables and single use items are becoming increasingly popular and may replace presently reusable items such as instruments, accessories, bottles, food utensils, linens, etc.

### Solid Waste Management

It seems to be difficult, if not impossible, for hospitals to maintain separate collection facilities for contaminated and non-contaminated wastes. As a result, all hospital wastes coming off the hospital floor must be considered contaminated and potentially hazardous. Ideally, therefore, wastes should be disposed of on-site or should be sterilized prior to off-site transport and disposal.(355) In practice, recognized pathological wastes and laboratory animals are ground and/or incinerated on site, but the vast majority of wastes are hauled by private contractors to landfill areas,(356) where they are for the most part mixed with household and commercial wastes.

In a survey of hospitals in the Washington, D.C. area(356) it was found that most hospitals use disposable refuse containers - plastic bags of 20 to 40 gallon capacity. They are seldom sealed with a metallic strip, however, and are easily torn. Furthermore, in all too many cases, unused pharmaceuticals and infectious wastes were not segregated and were disposed of with other general solid wastes.

In a survey of seven hospitals in Los Angeles County,(355) costs of waste disposal ranged from \$138 to \$390/ton of waste/day or \$1.94 - \$4.78/bed patient. Over 90% of the costs were attributed to manpower, exclusive of contract haulers.

A comprehensive study of solid waste management was carried out at the Los Angeles County-University of Southern California (356) Medical Center.(355) The nine-building complex contains 18 trash rooms, in each of which is a hinged-top portable cart of about 2-2.5 cu. yd. capacity positioned to receive waste fed by chute from the 3 to 20 floors above. As these carts are filled, empty ones are supposed to be moved into position, but more often than not, the loaded cart is overflowing and manual cleaning of spilled litter is required. Bags of waste often rupture, with occasional deposits of loose materials in the chutes. The latter also have to be manually cleared once in a while. The filled carts are moved into the corridors and hauled to a central storage area by tram. Non-grindable kitchen wastes in "trash cans" are similarly transported.

## TABLE I

## SOLID WASTES GENERATED IN HOSPITALS

- Metals
  - Needles
  - Razor blades and other blades
- Rubber
  - Gloves
  - Hoses and Tubing
- Plastic
  - Razors
  - Syringes
  - Bottles
  - Dinnerware
  - Bottle caps
  - Cups
  - Food trays
  - Bags
  - Straws
  - Gloves
  - Hoses
  - Styrofoam dunnage
  - Miscellaneous
- Wood
  - Packing Crates
  - Tongue depressors
  - Swab sticks
  - Chips (dunnage)
- Garden Trash
- Demolition Debris
- Radiological Wastes
- Paper
  - General office and packaging wastes
  - Newspapers and magazines
  - Sanitary sacks
  - Towels and tissue
  - Cups
  - Diapers and other disposables
- Textiles and Related Fibers
  - Rags
  - Gauze
  - Cotton
  - Face masks
  - Adhesive tape
  - Elastic items
- Glass
  - Bottles
  - Tubes
  - Syringes
- Molds and Casts
- Surgical
  - Pathological waste
  - Animals
- Incinerator Ash
- Food

Disposable syringes and needles, and all pathogenic wastes are collected in covered containers, and transported by hand cart to a disposal area.

At one time, unmixed refuse was incinerated on site, but after closing of the incinerator by the air pollution authorities, these wastes were hauled in a hospital compactor truck to landfill. Segregated non-combustibles, including syringes and needles in cans are also transferred to landfill. Pathologic wastes were supposed to be handled in a special incinerator, but during the time when this was down for repairs, these wastes too went to landfill. Roughly 20,550 lbs/day of disposable solid wastes were trucked to landfill, the truck making an average of 3-4 trips/day. Food preparation wastes (grindable) amounted to about 2,600 lbs/day. The pathologic wastes from surgery, authopsy, and laboratories totaled about 1,000 lbs/day.

Simplified Waste Classification

| Waste Stream |
|---|
| 61 |
| 66 |
| 10 |

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# VI. INTERVIEWS AND PLANT VISITS WITH INDUSTRIES ON WASTE MANAGEMENT

## INTRODUCTION

Interviews and site visits were conducted covering more than 45 industrial sectors. Some of these were telephone interviews and have been so referenced. These interviews and visits were made over a timespan from July 1972 through June 1973. They were conducted by various personnel of ADL at different stages in the development of the work on classification systems. The response of industry was a great variable. Some plant managers were exceedingly cooperative and generous with information, although they usually requested confidentiality. Others were extremely guarded and virtually refused to divulge any meaningful information. However, the objective of the interviews and site visits was not to compile data on waste management, but rather to obtain information that would help formulate a classification system and test its functionality. This objective was fully met.

The names of specific plants and persons supplying information have been deleted, to preserve confidentiality insofar as possible. The information quoted is presented only for its generic content, and should not be construed as a valid statistical sampling of any of the industries covered.

## PURPOSES OF THE SITE VISITS

The site visits were conducted in roughly three stages.

(1) Preliminary visits were made prior to any work on the classification system, in order to obtain from the field some perception of the requirements of a classification system in terms of functions to be served, and entities to be dealt with.

(2) Following a first version of a classification system, and inventory form, a series of site visits were made to test response and reaction to the format. This resulted in several cycles of change in the evolution of the classification system. The development of the system was further influenced by the literature surveys which are described elsewhere.

(3) A set of final site visits were conducted essentially using the draft final version of the classification system presented in this report. These visits resulted in some minor changes, and confirmed the practicality of the classification system in field practice.

While one purpose of the visits was to obtain information on industrial wastes not generally available in the literature, the major purpose was to demonstrate that the classification system in its present form, while short of perfection, can easily reduce the industrial waste information problem to manageable proportions, providing a logical and practical framework for future information inventories. While this objective has essentially been met, no claim is made at this stage to having solved all of the problems associated with obtaining industrial waste information. Most of these problems will remain independent of the classification system, and are discussed below.

## PROBLEMS OF IMPLEMENTING AN INDUSTRIAL WASTE INFORMATION INVENTORY

Information on the management of industrial processing wastes is not easy to obtain. In no case were we invited to survey the plant unescorted, and therefore we had to rely on the knowledge of the plant manager and his willingness to supply information. The extensive check lists that we prepared were extremely helpful in eliciting responses, and prior knowledge of the manufacturing operation proved essential in guiding discussions. Some of the specific problems encountered are enumerated below.

(1) Many production methods are considered proprietary. There is the fear that divulgence of a chemical analysis of waste material can only help competitive firms.

(2) Some plants are knowingly in violation of effluent discharge and waste disposal laws. Even while they may have plans for compliance, they do not want to go on record as self-admitted violators.

(3) At present, there is no systematic means for measuring and monitoring waste quantities. This problem is somewhat technical, but largely institutional. In general, industry will not routinely sample, measure, and record its wastes unless there is a compelling economic or legal reason for doing so.

(4) In the case of solid wastes, there is a need to establish procedures for sampling mixtures. Such procedures have to be adapted to a wide range of industrial production and waste generation.

(5) Most industries simply do not keep records that presently permit accurate estimates of [illegible]e generated in different categories.

(6) In general industrial respondents showed themsleves hostile to forms and resentful of the time diverted from essential duties for form filling. Some companies volunteer information to outsiders only under the auspices of the public relations department.

(7) When responding to questionnaires, "open-ended" questions tended to be answered superficially, or not at all.

The ultimate utility of the classification system will be a function of the quality of information to be obtained from industry. In none of the site visits conducted were we able to obtain on-the-spot completion of the inventory form. The industries simply did not have ready records which could be referenced. Where information did exist, it was usually scattered in different sources at the plant. It is significant, however, that most interviewees agreed that virtually all points of information requested could reasonably be obtained by instituting minor changes in operating and record-keeping procedures. Estimates on how long it would take to complete the inventory form varied from one to three days. Some of the plants in the chemical sectors maintained very detailed records exceeding the requirements of the inventory form.

A virtually universal sentiment expressed was that no meaningful information, whether or not they had it, was going to be divulged unless they were legally required to do so. There was considearble resentment of the fact that any information supplied to the EPA becomes public property. In contrast, industry feels that information supplied to the Bureau of Census is held in confidence.

## Industry No. 2011 and 2041 -- Beef Feedlots and Dairy Operations

Although the literature correctly identifies manure as the principal processing component from these industries, visits to the sites revealed that the manure is typically mixed with bedding material, ground cover, and other contaminants as follows:

### Bedding Material

- Straw
- Hay
- Saw dust
- Wood shavings
- Peanut hulls
- Chopped corn stalks

### Ground Cover

- Soil particles
- Stones
- Pieces of concrete
- Pieces of asphalt
- Plant parts

### Other Wastes

- Pieces of wood
- Nails, staples and wire
- Pesticides
- Antibiotics
- Disease organisms
- Maggots and other insect larva
- Dead carcasses or parts thereof
- Cereal grains and mixed feed
- Plastic syringes
- Paper products
- Baler twine
- Chlorine washing solution
- Livestock horns
- Urine

## Industry No. 2011 -- Meat Packing Plants

Three generic types of wastes were observed relating to the animal, plant operation, and the labor force. Disposal methods used include diversion to the sewer outlet, dumping into a waste body, burning and landfill. Specific waste components include:

### Related to Animal

- Manure
- Urine
- Feed (in stomach)
- Bones
- Blood
- Flesh (diseased as well as free from disease)
- Stones
- Soil particles
- Metal (in stomach)

### Related to Plant

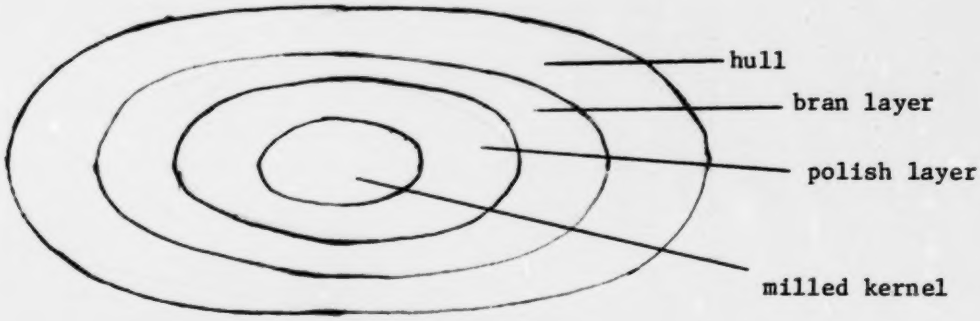
- Saw dust
- Wood shavings
- Paper & packaging material
- Conveyor parts (metal & rubber)
- Small amounts of organic and inorganic chemicals
- Pieces of asphalt
- Knives and saw blades
- Wood
- Soap & disinfecting compounds

### Related to Labor Force

- Clothing (primarily cotton fabrics)
- Rubber boots and overshoes
- Plastic gloves
- Work shoes (leather and imitation leather)

Industry No. 2044 -- Rice Mill -- California (Area Code 94124)

The structure of as-received paddy rice is indicated below:



Rice hulls constitute 25% by weight of total raw material production, and an even larger volume percentage. Milled rice has a density of 50 lbs/ft$^3$. The hulls are 8-10 lb/ft$^3$. The particular mill visited produces 12,500 T/yr of rice hulls, which are 96% silica, and hence deteriorate very poorly in landfill. The mill hauls 90% of the rice hulls in top-loaded highway van-type trailers, discharged with a chain belt. The hulls are combined with waste disposal sludge from the municipal sewer to make a good ground conditioner. Some hulls are presently combined with rice bran to get rice mill feed -- 60% bran and 40% hulls, used in the cattle and dairy industry.

A number of alternative waste disposal methods were discussed as follows:

(1) A company in Texas is using rice hulls and urea as a cattle feed.

(2) Rice hulls can be made into particleboard, but it is uneconomic. Large storage is needed and the board manufacturer should be adjacent to a rice mill.

(3) Rice hulls have been partially burned to form Greasesweep, a porous structured product that absorbs grease.

## Major Group No. 22 -- Textile Manufacture

In the following typical situations ranging from man-made fiber spinning to manufacture of textiles are discussed. The textile industry is apparently highly waste-conscious and relatively little is wasted before products reach the end-user, whether industrial or consumer.

## Industry No. 2281 -- Man-Made Fiber Products

About five billion pounds of man-made fibers a year are produced. Typically, the 7-10% of solid "wastes" are reused to a large extent.

| Step | Remarks | Disposition |
|---|---|---|
| Spinning | Low quality solid waste is produced on stop and start of spinning. | Even this material is largely garnetted (disintegrated into fibrous produce) and used for carpet backing. |
| Drawing | This results in higher quality waste. Less waste on staple than on filament manufacture. | Most waste is handled by waste dealers. Some is remelted in-house. Of recent, nylon and some polyester is reprocessed into plastic pellets for other uses. Much of the waste is garnetted and used in carpet manufacture. |

Industry No. 2282 -- Spun Yarn

| Step | Remarks | Disposition |
|---|---|---|
| Staple | Opened for spinning by processing through pickers, cards, slivers, etc. | "Fly" waste<br>Batting, stuffing materials<br>Some recycled<br>"Pneumofil" waste (spinning and drawing wastes as above) |

## Industry No. 2241 -- Weaving Mills

| Step | Remarks | Disposition |
|---|---|---|
| Warp | Peeling, sizing, etc. | 8% water soluble waste from sizing, No solid waste |
| Fill | | Essentially no solid waste |
| Loom | | |

## Group No. 225 -- Knitting Mills

| Step | Remarks | Disposition |
|---|---|---|
|  |  | Selvage trimmings, etc.<br>1-2% of total production |

## Group No. 226 -- Finishing

| Step | Remarks | Disposition |
|---|---|---|
|  | Scouring, dyeing, etc. | Less than 1% rag waste |
|  | Inspection |  |

Group No. 227 and 229 -- Carpets, Towelling

| Step | Remarks | Disposition |
|---|---|---|
| Shearings and Clippings | | Burnt -- about 3 million lbs/year |

## Major Group 23 -- Apparel

In the garment industry, cutting wastes amount to 5-20% of the fabric handled, depending upon style. In the case of the natural fibers, wool and cotton, virtually all of waste material could be recycled. Wool wastes can be reprocessed by specialists or mills. Cotton waste is at a premium for the manufacture of rag paper. Nonetheless, the industry suffers considerable loss in waste material, particularly in large plants.

## Industry No. 2295 -- Resin Impregnation -- California (Zip Code 94550)

The plant visited takes fiberglass webs and impregnates them with thermosetting resins to which dyes, sealants, and catalysts may be added. The impregnated cloth is partially cured, rolled up and sold.

### Plant Data

| | |
|---|---|
| Number of employees | 110 |
| Water consumption | 5,000 gal/day |

Waste treatment and handling facilities:

| Type | Year Installed | Capacity | Capital Cost | Operating Cost |
|---|---|---|---|---|
| •Baler | 1970 | 500 lbs/baler | $ 6,000 | |
| •Oven afterburner | 1969 | | 25,000 | $500/mo. |
| •Primary sewage treatment | 1950 | | 15,000 | |

The wastes from the plant fall into two basic categories:

I. Packaging Wastes and General Trash (500 T/yr)

| Material Constituents | Code No. |
|---|---|
| Phenolic resin | 22001 |
| Polyester resin | 22003 |
| Epoxy | 22006 |
| Other resin | 22019 |
| Polyethylene sheet | 21001 |
| Broken pellets | 31006 |
| Plastic coated paper | 33002 |
| Cardboard (70% of total) | 32019 |
| Fiberglass | 41005 |
| Graphite cloth | 42019 |
| Office wastes | 92000 |

These wastes are bailed on-site and trucked to the city dump by an outside contractor at a cost of $700/mo.

II. Leftover Resins (2,800 gal/mo.)

These used to be discarded in a private dump, but some dogs got into it and a different method of disposal had to be found. Finally, a Class A dump was located which accepts the material in 55 ga. drums. The manager feels the wastes should be incinerated, but there are no installations in California.

The resins typically contain 1-2% suspended solids and 40% dissolved materials. There are many formulations made up of one or more of the following constituents:

Resin compound--epoxy, phenolic, nylon-phenolic, phenolic-epoxy, etc.
Solvent--acetone, methyl ethyl futone, alcohol,
Catalyst--amines, peroxides, phthalic anhydride, etc.
Pigment
Filler--cab-o-sil (mostly), graphite, silica, carbon, etc.
Elastomeric additive--Hitco 158, acrylonitrile, Buna-rubber, etc.
Accelerator or Buffer

Most of the waste resins are uncatalyzed, and if anyone poured in an amine or peroxide, an exothermic reaction might result which could generate considerable smoke. Some of the mixtures are incompatible. If nylon were in solution and acetone were added, for example, the nylon could precipitate in a lump and the material would not pour.

The plant manager was keenly aware of the hazardous nature of the leftover resin wastes. In seeking an environmentally adequate method of disposal, he sent a letter to various disposal facilities describing the wastes and the handling hazards in considerable detail. Perhaps as a consequence of this, he experienced extreme difficulty in finding anyone to take the wastes.

## Industry No. 2361 -- Linerboard Manufacture

About 10 million tons per year of linerboard are produced in the United States. The following deals with the manufacturing operations starting with wood and continuing on to rolls of linerboard. A typical mill would make 1,000 tons per day of linerboard in an integrated kraft pulp mill-linerboard machine.

| Step | Remarks | Disposition |
|---|---|---|
| Wood Harvesting | About 60% of the tree weight is left in the forest. | The residue wood from the logging operations is either burned or left to decay and return to the soil. |
| Wood debarking | About 10% of the wood is lost in the debarking operation. | The bark is generally burned for its fuel value, although in some cases it may be left in piles to decay or may be treated to produce a mulch product as an article of commerce. |
| Wood chipping | Some fines, too small for use in pulping, are produced in the chipping operation. | The fines are burned with the bark or in some instances may be pulped in special digesters. |
| Pulping operation | In the kraft process organic sulfur compounds are produced which are vented and, unless special precautions are taken, appear in the atmosphere. | Until recently the volatile sulfur compounds were simply vented to the atmosphere, but now these gases are collected in some cases and rendered odorless by putting them through the lime kiln, for example. |
| Pulp washing and screening | Screen rejects are recycled either to the digester or to refiners which reduce them to pulp. The solution of pulping chemicals and dissolved organics is collected at as high consistency as possible. There may be small fiber and organic and inorganic chemical losses at this point as well as some volatiles appearing in the gas stream. | To the sewer or to the atmosphere, as the case may be. The sewered material may be collected and put through settling lagoons and then may be subjected to aeration or some other secondary disposal system. |

| Step | Remarks | Disposition |
|---|---|---|
| Black liquor burning | The black liquor is sprayed into a furnace and burned. The furnace is operated under a reducing atmosphere as a smelting furnace so that a molten smelt of sodium sulfide and sodium carbonate is collected from the bottom. Sodium sulfate, volatile sulfur compounds, and nitrogen oxide compounds are produced. | As much of the sulfate as possible is removed from the gas stream in Cottrell precipitators on the top of the stacks. The gases may be stripped to remove the volatile sulfur compounds. |
| Liquor recovery | The molten smelt is dissolved in water, treated with burnt lime, settled and then decanted to provide sodium hydroxide-sodium sulfide solution and calcium carbonate. | The calcium carbonate is collected and sent to a lime kiln where it is converted to burnt lime. |
| Linerboard manufacture | The washed pulp is put through the paperboard making operation along with alum and rosin size to produce linerboard. About 20,000 gallons of water per ton of pulp are lost in the board making operation. The water contains some fines plus residual chemicals from the paper-making system. | The effluent from the paperboard machine is put through the settling lagoon and secary effluent treatment facilities, if available. |
| Black liquor evaporation | The recovered solution (black liquor) from the pulping reaction is evaporated prior to burning. The condensate contains offensive sulfur compounds. | The black liquor is sometimes oxidized to fix the sulfur compounds so that they do not appear in subsequent handling steps. Without black liquor oxidation, the evaporated condensate is generally handled in such a way as to minimize water pollution. |

## Industry No. 286 -- Chemical Plant -- Michigan

A visit was made to the solid waste disposal facility of a chemical company in Michigan. Discussion of waste generation is greatly facilitated by considering packaging and processing wastes separately.

The plant has an exceedingly sophisticated waste disposal system, built around a rotary kiln incinerator, a liquid waste burning incinerator, and a private landfill. They are keenly aware of the chemical, physical, and toxic properties of their wastes, and use the knowledge to advantage in their solid waste management program.

Packaging wastes are for the most part incinerated. However, 55 gallon drums, if they contain no toxic material, are sold to a drum wash outfit and re-purchased as containers for waste liquids. Contaminated drums are incinerated.

For every processing waste generated in the complex, a form is filled out and filed. The form identifies (1) the process, (2) the building and exact spot or room where the process is carried out, and (3) the residue source (e.g., still bottoms, wash residue, residual tar, filter sludge, insoluble oils, etc.). Any waste with a melting point below 150°C can be handled as a liquid, and is transferred to the waste disposal area in heated dump trucks. Physical characteristics recorded (8) are specific gravity, flash point, melting point, and viscosity (presumably at the temperature at which the waste is handled). Chemical properties recorded (9) are heat of combustion, ash content, % chlorine, % moisture, and pH (actually acidity or alkalinity in g-eq./l). Space is provided on the form for the specific chemical composition of the waste, i.e., chemical compounds present and weight percentages. Potential hazards in handling, if any, are described (11) and potential hazards of mixing with other residues are evaluated (12). For example, sodium chips should not be mixed with high moisture residues; organic residues with active groups must be handled with knowledge of the types of reactions possible, etc. Finally, quantitative data on the rate of waste generation are provided (13). Data sheets are on file for 500 - 600 high volume wastes. Low volume wastes are not catalogued, but the generator is responsible for arranging proper handling.

In managing the wastes, when a truck arrives at the central disposal site, the driver gives the location from which he is coming (building no., spot no., or door no.). The site manager then instructs him on where to dump -- usually into one of three hold tanks, into a pit, or onto a concrete platform (drummed or bagged waste). In general, really hot residue is kept away from low boilers. Residues with reactive groups are kept separate. High ash material might be kept away from low ash material. Small quantities of drummed explosives are fed into the rotary kiln in a controlled manner.

There is a pathogenic incinerator for animal testing wastes, which are handled separately. The pilot plant keeps its own records for waste management purposes. Waste cholinesterase compound, which affects the white blood corpuscles, is packaged at the plant so that there is no human contact with it.

The firm provides consulting services to private industry on solving solid waste problems. They have developed a number of proprietary analytical procedures which they feel are improvements on currently used methods.

Phenols from brines generated in phenol manufacture present a particularly difficult waste disposal problem due to taste and odor imparted to water even in minute concentrations. The company is working on the problem. They have trickling filter and activated sludge treatment facilities as well as the solid and liquid incinerators.

Some of the specific wastes which are incinerated were mentioned, although most of them are considered proprietary. The company makes styrofoam and a great deal of foam is burned. Today, many tars are burned to provide heat for distillation columns. Diluent oils are used to burn tars. A chlorinated tar burner has been built. Stringy materials -- long, fibrous materials, such as films that tend to ball up, must be cut up into 6 foot lengths prior to incineration. Otherwise, they can act as fuses and cause fires in the incinerator feed shoot. Powders and cakes are another type of waste.

The following data are now obsolete and do not represent current experience by the plant or even necessarily current manufactured products. The information does give a general indication, however, of the type of processing waste that might be encountered in chemical manufacturing.

| Product or Plant | Processing Wastes |
|---|---|
| Propylene Dichloride | 1. Still residue; liquid; 52% Cl, 0.02% ash<br>2. Light fraction; clear; low boiling point; 80% Cl; 0.01% ash |
| Aspirin | 1. Batch still wash residue from acetic acid stills; liquid above 60°C; contains acetic acid<br>2. Methyl salicylate waste -- batch still residue; solid is drummed; phenolic tar; contains sulfuric and salicyclic acids<br>3. Lab wastes -- organic solvents and tars; mixture of 75% NaCl and 25% epoxylated compounds; toxic |
| Diphenyl Oxide (DPO) | 1. Liquid DPO tar containing 1-2% NaCl, 0.6% ash; ortho phenyl phenol |

| Product or Plant | Processing Wastes |
|---|---|
| Sodium phenate finishing | 1. Still residues |
| | 2. Insoluble filter sludge, sent to a phenol pond |
| | 3. DPO tar |
| | 4. Phenylphenol liquid tars; solid at room temperature; 0.6% Cl; 6.37% ash; some sodium salts and substituted phenols |
| | 5. Celite filter and sludge -- filter cake with iron precipitate, aluminum precipitate and water wash |
| Aniline | 1. Still residues -- DPO; azobenzene; diphenylamine; some NaCl; high boiling tars, solid below 100°C |
| | 2. General distillation wastes -- mostly DPO; liquids; used to thin tars |
| | 3. Sump cake wash -- aqueous solution with aniline contamination |
| | 4. Insoluble chloroanisole oils; 3.25% Cl |
| | 5. Waste isomers mixture; dichloronitrobenzenes; 3,4 oil corings |
| Diphenyl Distillation | 1. Ortho phenyl phenol still bottoms; tar; 15% $Fe_2O_3$ ash; 17-19% NaCl; the ortho-compound |
| | 2. Para phenyl phenol still bottoms -- tar; 10% NaCl |
| | 3. Butyl phenyl still tar bottoms |
| | 4. Meta oil tar |
| | 5. diphenyl still bottom -- some water |
| Chlorinated Phenyl Phenols | 1. Phosphorous oxychloride |
| | 2. Methylene dianiline tar |
| | 3. Monochloropara phenyl phenol tar |
| | 4. Ditertiary octyl diphenyl oxide |
| | 5. Phosphorous chips |

## Industry No. 2834 -- Pharmaceuticals -- New York, Connecticut, Indiana (telephone interview with three plants); New Jersey-Site Visit

### A. Connecticut

At the Connecticut plant, the largest tonnage is in antibiotic mycelium mixed with filtercel. They also have a large quantity of gypsum (obtained as a by-product in the recovery of citric acid) which is reasonably pure. At the moment this is disposed of in landfills, but they are negotiating with someone who may be interested in buying this material and recycling it. There is also a large volume of activated carbon and filtercel which is a by-product of decolorization and purification steps in various antibiotic and synthetic organic processes. A rather unusual by-product is the soot from the boilerhouse. This material contains fair quantities of vanadium and might be useful as a source of vanadium. Presently, it is disposed of in landfill. They have a large amount of cellulosic material consisting of broken wooden pallets, paper, especially 100 lb. shipping sacks and cardboard cartons. The computer paper and the IBM cards are valuable and are easily sold. Only a portion of the other mixed paper can be sold and most of it is put through an Eidal shredder which is run by the municipality. One of the principal difficulties in recycling paper has been the possible content of pesticides or treatment chemicals. They have been experimenting with various uses for some of the packaging material such as the production of potting soil by using styrofoam or ground glass in place of sand. They are also experimenting with various composting schemes.

### B. Indiana

The Indiana plant has similar materials to be disposed of such as mycelium and filtercel. However, they are presently burning coal so they have a considerable quantity of ash that must be disposed of on their own landfill. The plant will be converting to oil so this material will no longer be a disposal problem. A material which was mentioned at the plant is approximately 3,000 to 4,000 gallons per month of still bottoms. At present, these are burned but they would like a better disposal method. (It is probable that still bottoms are also obtained at the Connecticut plant but were probably overlooked since they are usually liquid materials.) This plant also has an experimental farm attached to it and they have the problem of disposing of test animals. They also have permission to bury certain low level radioactive isotopes that are used in the animal tests. The plant has a large salvage operation which recovers for internal use many valves, fittings, pipes, etc. They sort most other metallic materials for sale to dealers. Trash that is disposed of in the County landfill area is run through their compactor before trucking to the site.

### C. New York

At the New York plant, the mycelium from the citric process is sent to landfill. Gypsum is discharged to the sewers and becomes a dissolved solid in the large interceptor sewers. At present, they are not operating the Somat grinder because of the sewage load it produces. Instead, they truck away rejected pharmaceuticals, syringes, needles, etc., mixed with papers, cartons, etc., in a so-called "witness load". Witness loads are accompanied to the landfill site by a pharmacy representative who witnesses the burial of the load to prevent "pickers" from recovering items for sale. Industry practice is now going to the use of Eidal dry tape grinders to make the destroyed material unsaleable. They plan to use this system in the future. Metal scrap is sold but no corrugated cartons are currently recycled.

## D. New Jersey

The facilities visited reported that all solid wastes, with the exception of solvents and metal, were sent to a private dump. In fact, a good deal of waste went to the municipal sewer.

Metals, consisting of copper pipe and scrap, steel filings, bittings and valves, etc., are sent to a junk dealer. Solvents for the penicillin operation are recovered on site. Other waste solvents, amounting to about 50 drums/yr, are sent to a disposal/recovery company. The research laboratory puts their waste solvents into separate bottles, which are in turn collected in drums prior to being sent out for disposal. Waste lubricating oils, generated in small quantities, were formerly sent out for disposal, but are now being burned in the company boilers.

The wastes going to the municipal sewer system includes filtercell mycelium and cream and ointment residues.

The company has, in a special waste handling area, a Somat machine and a Centriblast. The latter is a rotary hammermill which can't be used on products that generate a lot of dust. The Somat is used for glass as well as paper, although there must be lots of cardboard in the mix when the machine is run. Off-spec, out-of-date, or surplus product is run through a grinder prior to dumping.

The major plant waste is packaging. Empty bags, in which chemicals are delivered are typically contaminated with such things as calcium carbonate, ammonium sulfate, and various phosphates. Drums, which have contained only solids protected by plastic bags are sold to a drum reclaimer. Contaminated drums and any drums marked with the company name are dumped.

In the last few months of 1972, an average of 1,200-1,400 cu. yd/mo. of compacted Centriblast, office, and packaging wastes were generated, together with an additional 350-500 cu. yd/mo. of special wastes from the Somat, tree prunings, construction and demolition, etc.

## Industry No. 2851 -- Paint Manufacturer -- California (Zip Code 49080)

The plant manager reported that 123 dumpsters/year (8' x 6' x 15') take all solid and semi-liquid wastes. The latter are in a semi-gelled form and are emptied into drums for dumping. Obsolete paint colors are sold to a broker who sells outside of the United States. Off-quality paint is given away.

### Plant Data

Number of employees 400
Waste treatment and handling facilities:

1. Afterburner--handles solvents that evaporate from resin manufacturing tanks
2. Water treatment (planned)--system to flocculate water based resins; sludge will be hauled to a dump

### Waste Handling and Disposal

The solid and semi-liquid wastes are trucked to the municipal landfill by a contractor at a cost of $7,000/yr. Internal handling costs run $35/day for labor. An enormous variety of wastes that would have to be classified as hazardous are handled in this way. A typical dumpster load might include:

Pigments--These consist of oxides of aluminum, iron, copper, lead, tin, mercury, titanium, magnesium, molybdenum, silicon. Some cling to the paper bags from which they were originally emptied. About ten 500 gal. drums/wk. containing a 30% pigment sludge are dumped, as well as knife blades and filter bags impregnated with paint.

Organometallics--Cobalt napthenate, zirconium napthenate, organic platinum complex.

Still bottoms--fatty acids, aromatic acids, aliphatic and aromatic hydrocarbons, halogenated hydrocarbons, aliphatic amines, analines, pyridines, aldehydes, ketones, organic sulfur compounds, cyanides, thiocyanides, and cellulose.

Resins--polyethylene, cellulosics, nitrocellulose, phenolics, alkyds, urea melamines, etc.

Other--carbon, asbestos, broken pallets, plastic-coated paper, small beryllite or flint millstones, inks.

## Industry No. 2911 -- Oil Refiners -- Louisiana, California (Visits) and Texas (Telephone Interview)

A. Louisiana

The firm purchased this plant in 1955 and have treated the water ever since. API separators were installed in 1920. Total capital costs for water pollution abatement since 1969 have been $2,400,000, distributed as follows:

| | |
|---|---|
| API separator for coker (1969) | $ 152,500 |
| Effluent water treating facility | 371,800 |
| Desalter separator | 114,000 |
| Caustic neutralization | 170,000 |
| Equalization tanks for disposal wells | 80,000 |
| Miscellaneous (revising sewer systems, etc.) | 148,800 |
| Water retention | |
| Change in disposal well #1 | 1,390,000 |
| Paris ditch skimmer | |
| Base cooling water for pumps | |
| Total | $2,427,100 |

Primary separators recover oil, which is recycled.

The solid waste "batches" were identified as:

A. Office and cafeteria wastes -- sent to the County landfill;

B. Spent Caustics -- some are neutralized and disposed of via deep well injection techniques; others are sold;

C. Separator Sludge -- disposed of on-site in a large settling basin; used to build dikes around the refinery and for landfill;

D. Scrap iron -- sold.

### Spent Caustics

These are by-products of caustic treatment processes, and are of the form (ArONa). Those that can't be sold are neutralized with

$H_2SO_4$, and are separated out into an oil layer and an aqueous layer. The oil is recovered; the aqueous layer is disposed of by deep well injection. The high grade cuastics contain chrysillic acids, which are sold for use in plastics. The naphthenic caustics are neutralized. A typical naphthenic caustic has 17-20 g/l of alkylate; 120-105 g/l of naphthenic acid, 120 ppm of phenols. It has a pH of 12-13, a COD of 278,000 ppm, and is 70% biodegradable. Naphthenic wastes are generated at about 5.8 gallons/minute.

### Separator Sludge

No quantitative data are available. The plant has installed flight scrapers on the main API separator which allows recovery of more sludge. Additional treatment facilities may be needed. The normal procedure is to dewater the sludge on site in a pit. The properties of the sludge are:

BTU - none
Temp - x
Density - ?
pH - 8.5-9 (solution in contact with the sludge)
BOD - some due to oil entrainment
COD - some due to oil entrainment
SS - 150 ppm in the separator, 50% drop out; solids absorb some oil

Chemically, the sludge consists of silicates (sand and silt), organic matter and oily water run-off. Clay, from kerosene operations, is used on site for building dikes and landfill. There is some oil entrainment.

### Refinery Gases

A smokeless flare is used.

Natural gas and some process gases are used for fuel.

### Phenolic Wastes

These are found primarily in sour waters, containing ammonia and sulfides. They come from various processes, principally in the water condensate from fractionation. The pH is around 3.5. The wastes are generated at a rate of about 150 gal/min. They are mixed with the caustic wastes in an equalization tank, and disposed of by deep well injection.

### Coke

This is the end product of refining. It is dumped across the wall to an aluminum plant to be made into electrodes.

## B. California

The interviewed personnel were perfectly willing to talk about solid waste management in refineries generally, but most reluctant to discuss their own plant. They were particularly eager to point out the recycling potential of refinery wastes, although the interviewer did not get the impression that there was much recycling in practice. It was mentioned that catalyst fines, mainly $SiO_2$-$Al_2O_3$, can be used for ground fill. Separator sludge, a mixture of solids and oil, can be spread on the ground and biologically decomposed (bacterially degraded).

Spent caustic is neutralized. The $H_2S$ is flushed off and goes to a sulfuric acid plant nearby. Oil is taken back and recovered. $Na_2SO_4$ now goes into ponds. About 200-600 barrels/day of $Na_2SO_4$ are produced.

The pond water has been analyzed for the Corps of Engineers for oil and grease; $F^-$; pH; chrome; hexachrome; sulfur; phenols; $NH_3$; COD; flow; temperatures; SS; BOD; Pb; Fe; etc. The $NaSO_4$ might be used in paper mills. Sometimes it is sold for recovery of chrysillic acid. Acid sludges are treated to get sulfonates which are burned to make sulfuric acid at the nearby plant.

Hydrorefining is becoming more popular. This involves hydrogenating everything over a catalyst, so that sulfur goes to $H_2S$; $N_2$ goes to $NH_3$; phenols go to hydrocarbons, etc. This eliminates the need of clay treatment. The hydrorefining catalysts, Co-Mo and Ni-Mo, are sent to reprocessors. These catalysts last 1-5 years and present a very minimal problem.

Wastes that are disposed of on land include catalysts and FCC (fluid catalytic cracking) fines. These are mainly $SiO_2$-$Al_2O_3$ which come out of a regenerator and have been heated to 1300°F. They are produced at about 2-3 tons/day. They are picked up by a private contractor and may be kept on site or taken to landfill.

Oily sludge from the API separators and tank bottom cleanouts are collected separately. Other liquid wastes from the lube business are burned for fuel.

The California refinery, unlike the one in Louisiana, goes to asphalt, not coke.

Metal wastes - obsolete equipment and machine shop turnings are reclaimed. Organometallics go into asphalts or drop onto the catalyst in hydrorefining.

Industry No. 2911 -- Oil Refining -- Texas (Telephone Interview)

Any oil that is recoverable is recovered. Much of the processing solid waste consists of mineral material dirtied with very inseparable oil and tar. The "tank bottoms" consist of tar-contaminated dirt, scale, and spent silica and aluminum catalyst material. Similarly, the "filter solids" are oily clay, silica, etc. The plant uses river water and before this is returned to the river, oil is removed by a separator. The "separator sludge" consists of river mud or other such solids. The use of once-through water in refineries is fast diminishing.

There is some metal scrap from machine shops, failed equipment, and pipe work. This is roughly separated into iron, copper, brass, etc., and sold to outside metal salvage companies. The small amount of Pt catalyst is carefully reclaimed.

The $SiO_2$-$Al_2O_3$ cracking catalyst is cleaned (to remove C) and separated in-house. If the particle size distribution has been degraded but the catalyst is still relatively clean, it may be returned to the catalyst manufacturer. While a classification system might be of future use in classifying and separating domestic waste, the manager felt that as far as refineries are concerned it would only be more forms to fill out.

Industry No. 3079 -- Plastics Production -- Louisiana, Illinois, Massachusetts

ADL Personnel met with the Chief Engineer who is responsible for all company facilities. The company produces polystyrene, nylon 6, expandable polystyrene, and will be in commercial production of ABS in the near future (currently it's a pilot plant operation). The company produces monomer in Louisiana (styrene), polystyrene in Illinois and Massachusetts, and a new plant is under construction in Virginia. Sunglasses are also fabricated in Massachusetts, and cottage cheese containers are formed from impact polystyrene in Ohio. Thus, this company is involved in monomer production, polymerization, and fabrication.

Three categories of waste are produced from polystyrene:

1. A scrap plastic fraction. This is produced from their finishing operation, which involves extrusion. It is in the form of strands, "pigs", and pellets. The plastic waste is usually contaminated with colorants, additives, and dirt and represents less than 0.5% of their production. The company keeps account of this material. When first generated, it is kept separate in the plant, but when it is brought outside of the plant building to a bin on the grounds, it is mixed with other wastes. Thus, potentially, this waste product is available as a relatively clean stream. The less contaminated plastic scrap is sold to reprocessors.

2. Trash. This is the major waste and amounts to 20 to 50 times the volume of the first category, but the plants generally do not keep records. This is primarily packaging material [illegible] cellulosic waste. Both wood and paper account for between 80 and 90% of this waste stream. Other contaminants are plastic, rubber, perhaps a small amount of glass -- a dry rather than a wet waste. Again, this waste is kept separate inside the building but is mixed outside. It is usually mixed with the first category waste. The trash has a considerable amount of corrugated stock (between 25 and 50%) which is a valuable paper stock.

3. Sludge. This is derived from their waste treatment facilities. They treat all of their process water and it then goes into the sewer system. The solids content varies between 15 and 30%. These solids are approximately 70% plastics and organic materials and 30% inorganics, including phosphates, calcium hydroxide, etc. The number of components in this category is probably less than 10 and perhaps as many as 5. They keep records of the volume of these wastes, which amount to about four times that of the first category.

A private scavenger picks up the waste that has been combined on the outside of the plant building. This service costs $35,000/year. Waste from the research laboratory as well as waste from the fabricating facilities are combined, and the salvage bill is shared by these three groups.

All of these wastes are hauled to a landfill operation, which is public but the city maintains a separate site for these wastes. The sludge wastes are handled by the company's own truck, and again they use a separate site for category three wastes.

The waste streams in their nylon 6 production are similar, except that there is essentially no category three wastes. ABS and expandable polystyrene have waste streams similar to the three for polystyrene. The fabrication operation in Massachusetts where sunglasses are made produces a scrap plastic stream which also amounts to less than 0.5% of their total production. It, too, is maintained in a separate bin in the plant and then combined outside of the plant facility. Most of the fabrication plastic wastes are recycled, because converting and fabrication operations are carried out in the same plant, both in Massachusetts and Illinois. In the nylon 6 facility, where film is made, most of the scrap is sold, because it can be depolymerized back to the monomer.

In the Illinois operation, there is also a water treatment set-up. However, the solids concentration in this sludge is at most 5%. These solids consist of additives, monomer, etc. The water treatment facility from the sunglass operation includes waste from electroplating. Therefore, this sludge contains polymer as well as metals such as chromium, nickel, and silver in very small concentration.

Trash is also the major waste stream from fabrication and is similar to that from polymerization. However, that from the sunglass trash stream contains a high concentration of glass.

Laboratory wastes are generally segregated if they are judged to be hazardous by the laboratory personnel. A separate landfill site is operated to dispose of this material.

The waste from monomer production is primarily viscous liquid "bottoms". The company pays to have this hauled to a reprocessor. Little of this becomes part of the waste stream. The spent catalyst from this process is a disposal problem, but they do not know what happens with it, because the problem is handled by the reprocessor. Trash wastes from the monomer operation are minimal.

Metal scrap (pipe, gears, etc.) from the various plants is segregated and sold. Obsolete inventory is also sold.

## Industry No. 3111 -- Tannery -- Iowa

The company employs 102 people. ADL personnel talked with the plant manager, who was familiar with every aspect of the company operations, and conducted a complete tour of the plant.

The principal packaging wastes are twine, used to tie together stacks of green salted hides for shipment from the slaughterhouse to the tannery; large cardboard boxes, used for shipping frozen hides; metal drums, and paper bags, in which chemicals are received. The twine and paper go to landfill, and the metal drums are sold by competitive bid, usually for about 35¢/each.

Office Wastes - are sent to landfill.

External Maintenance Waste - (grass clippings and tree prunings) are handled by a yard man on a contract basis. They are either composted or taken to landfill.

Construction and Demolition Debris - is loaded into fiber drums and taken to landfill.

Processing Wastes - from the tanning operation per se are primarily liquids, which are pumped to a special handling facility incorporated as part of the City's waste water treatment plant. After tanning, however, the skins are dried and split (cut to uniform size). The leather scraps are baled. When 250 bales have been accumulated, they are loaded onto a truck and sent to a company which pulverizes them for sale as fertilizer extender.

The surface of the tanned hides is shaved off or scraped to assure uniform thickness. The shavings, which do not bale well, are hauled to a dump by the City. Leather dust from a sander is also collected and sent to the City landfill.

The tanning effluent liquor is coarse screened prior to entering the liquid waste treatment system. From 1/2 to 3/4 cubic yards/day of grease and leather scraps (primarily grease) are caught on the screens and collected in drums, which are hauled away by the City.

The alkaline sludge, resulting from lime precipitation of the chromium wastes in the tanning liquors, is handled together with normal sewage sludge. The combined sludge is maintained at pH above 8.5 to assure retention of chromium as a solid precipitate, and is hauled by truck to landfill.

## Industry No. 3334 -- Aluminum Plant -- Louisiana

This plant used to have a big dump in which wastes were burned. Now, they have a contractor to haul miscellaneous wastes to landfill. They also have a salvage yard for metal and equipment residue and pieces which are sold to a scrap dealer. Copper waste from the machine shop is used as an alloying material. Aluminum waste is fed back to the pots. Wood wastes from the shop operations goes to landfill. Concrete wastes (worn out floor slabs) are left outside. Rubber and packaging wastes go to landfill.

### Processing Wastes

The plant makes aluminum in 1300 reduction cells. Each cell is hooded and has a gas withdrawal system with a water scrubber. To avoid water pollution problems, the company plans to switch to dry scrubbing with $Al_2O_3$. The off-gases are typically fluorides, carbonaceous materials, particulates and aluminum. If dry scrubbing is used, the gases can be recycled.

The aluminum goes to the casting department where it might be cast into pig or go into chlorination furnaces. A dross consisting of some aluminum and flux salts ($NaCl$, $KCl$) is generated in the chlorination furnace. Dross may be sold to a recycler. Residual slag gets hauled to landfill. Off-spec aluminum is remelted.

During the making of extrusion billets and during continuous casting, saw chips are generated. These are remelted, but only with a great deal of difficulty. Redraw rod (3/8") is remelted.

The lining of the aluminum cells is anthracite coal and pitch. It tends to pick up molten cryolite, and eventually fails. The Company once had an on-site plant to recover cryolite from the spent linings, and to synthesize cryolite from purchased phosphate rock wastes. They were discharging ground up carbon to the river. Now, they cannot do this due to water pollution laws, and they are stock piling the carbon pot linings. They are thinking about installing a roaster to burn the carbon to $CO_2$; the "calcine" would go back into the process. The facility would cost $2.5 million. If they do resume operation of the recovery plant, carbon will be hauled to landfill.

One by-product of cryolite manufacture from sodium silicofluoride is an $SiO_2$ impurity, which is compacted and sold to a sulfur firm. A desilication product (DSP), sodium aluminum zeolite, from cryolite manufacture is hauled to landfill. If the dry scrubbing process described earlier is successful, the need for virgin cryolite will decrease. There is a caustic waste from cryolite manufacture which is normally discharged as a liquid -- an aqueous solution or a slurry containing spent limestone. If the caustic were regenerated with oyster shells, there would be a solid waste problem. A water treatment facility might yield $CaSO_4$ and $CaF_2$ (mostly).

The firm calcines coke to manufacture their anodes. They are trying to burn the carbon particles. In a rotary calciner, aluminum silicates are emitted. These are small in concentration and may come out of the coke in the refractory lining. Off-gases are scrubbed with river water. Other places use wet lime.

The company dump is just outside of the gates of the manufacturing plant, and contains a mountain of used pot linings. The typical pot bottom typically lasts 1000 days (3 years), and as indicated above presents a difficult disposal problem. Miscellaneous wastes on the dump site include concrete slabs with reinforcing rods, rubber tires, wood pallets, tree prunings, air filters (metal and fiber), and plywood. These are compacted on site and sent to landfill.

## Industry No. 3519 -- Engine Manufacturer

The plant described in the following would typically supply 50 to 120 hp engines such as used in tractors, compressors, etc. There is very little non-recycled scrap. The plant might typically produce 20,000 to 50,000 units per year. Average weight of engine is 500 lbs. Zinc die castings, fuel pump, carburetors, etc., are purchased.

| | % Yield | # Total | # Waste |
|---|---|---|---|
| Castings | 50 | 300 | 150+ |
| | 25 | 125 | 30++ |
| Wrought Stock | 50 | 50 | 50++ |
| Sheet Metal | 30 | 40 | 12++ |
| Aluminum/Zinc DC<br>Fuel pump<br>Carburetor<br>Buy, not make | | | +++ |
| | | | 242 |

+ Waste unless recycled to a captive foundry
++ To scrap dealer
+++ Small amounts of miscellaneous scrap

## Industry No. 3523 -- Tractor Plant

This plant produces 50 to 100 hp tractors at the rate of 10,000/yr. Tractor weight typically may be 3,700 lbs. Of this, 2,100 lbs. are purchased parts, namely, engines, transmissions, tires, trim, electrical equipment and differential. In the following table scrap generation and utilization are characterized. It should be noted that the scrap utilization is extremely high, which is typical for many heavy metal fabrication plants, such as engine, transmission, etc.

| Operation | Type of Scrap | Yield % | Yield Lbs. | Total # Waste |
|---|---|---|---|---|
| Forging Dept. | | 75 | 150 | 35+ |
| Axles | | | | |
| Pedals | | | | |
| Hitch | | | | |
| Sheet Metal | Cuttings, notchings of mild steel sheet metal | | | |
| Hood | | | | |
| Cowling | | | | |
| Seat | | 70 | 200 | 60+ |
| Grille | | | | |
| Machinery Dept. (all forgings) | Low alloy steel milling chips lathe turnings | | | 8+ |
| Cast Cases | Cast iron 'powder' | | | 15++ |
| Shafting | Lathe turnings | | | 10+ |
| Gears, Trim | | | | 10+ |
| Miscellaneous | Some organic sheet-minor copper wire trimmings | | | |
| | | | | 138 |

+ Goes to scrap dealers

++ Trash

## Industry No. 3585 -- Home Air Conditioner Plant

The most popular size would be a 8000 BTU conditioner weighing about 100 lbs. with a plastic ornamented or wood imitation panel facing the inside. Typical production rate would be 250,000 units per year. Waste generation is summarized below:

| Component | Materials and Remarks | Solid Waste |
|---|---|---|
| Case | Vinyl covered sheet metal, molded ABS, styrene,<br>Zinc die castings, Chromium plated castings and plastic<br>Insulation, fiberglass or urethane foam | 12 lbs/unit trash |
| Sealed Compressor | Purchased | Copper tubing ends 2 lbs. to scrap dealer<br>Connecting wire Scrap, etc.<br>Packaging Material 1 lb. trash |
| Air Moving Equipment | Motor, plastic squirrel cage, aluminum fan, galvanized | 4 lbs. trash |
| Coils | Aluminum and copper tubing | 5 lbs. to scrap dealer |

## Industry No. 3674 -- Electronic Components -- Texas

This firm generates a multitude of wastes from its chemical and electronics manufacturing operation. It divides its waste into four main categories: paper, wood, metals, and chemicals. In the process of its day-to-day operations, the plant generates some 20 tons of paper waste. All paper wastes are divided into secret, internal, and general categories. The secret documents are placed in special bins located at various points around the site and are then transported to an incinerator where they are burned. Internal documents go into special yellow baskets located around the site, and these documents are then sent to a shredder. The documents go from the shredder to a dumpster located behind each building. General paper wastes go into wastebaskets which are emptied directly into the dumpsters. The only things that are permitted to go into wastebaskets at the facility are paper wastes and wastes from vending machines. The firm very strictly enforces this rule. The paper waste dumpsters are periodically hauled away to a municipal dump.

All wood wastes are kept segregated from any other type of waste. Wood wastes are disposed of in wood dumpsters that are located behind each building. These wastes are periodically carried off by a private contractor for disposal. The exact method of disposal was not known.

The company generates large amounts of metal wastes in its manufacturing operations. Much of this waste is made up of gold, silver, and copper. All metal wastes are dumped into special disposal receptacles which are located in various parts of the facility. This material is placed into dumpsters located behind the manufacturing buildings. Refiners pick up these metal wastes for reprocessing. Waste copper is currently being purchased for $0.33 a pound and brass for $0.47 a pound. The gold and silver prices are in the process of being renegotiated. Rules concerning the disposal of all metals are quite strict. A very strict accounting is kept of all the waste metals that are generated, in order to insure that the refiner honestly reports the revenues earned in the selling of these wastes.

The dumpsters for components which contain silver and gold are locked, and the keys are kept by only a select number of people. These dumpsters are located behind the semi-conductor building. Other metal wastes are disposed of in dumpsters behind the buildings from which these wastes are generated.

The firm consumes a large number of chemicals in its day-to-day operation. These chemicals are used for plating, etchings, and as raw materials for the making of the basic semi-conductors. All chemicals used by the firm are purchased and then distributed to the various Texas plants. Chemical wastes generated by all the Texas plants are returned to Dallas for recycle and/or disposal. Currently, acetone, and chlorinated and fluorinated solvents are kept segregated from all other chemical wastes. Whenever possible, these wastes are redistilled and recycled into the operation. If it is known in advance that a large amount of chemical waste is going to be generated by a particular operation, special efforts will be made to keep this waste separated from the other common waste streams which are usually incinerated. Those wastes which cannot be recycled are hauled away by contractors for incineration. Currently, the plant has three separate contractors for hauling these wastes.

They are currently trying to sell chemical waste that they have been unable to recycle. The City has published a list of manufacturers for the greater Dallas area that gives company names, phone numbers, and products produced. Based on the information contained in this publication, the plant facilities director is attempting to discern which companies might have need for some of the waste streams generated and to contact them to see if they would care to purchase any of these wastes for their operation. Likewise, the facilities director is also trying to determine whether any of the wastes generated in the area could be used, and is approaching the generators to see if they would be willing to see their wastes.

The containers that are used to ship the chemicals are often disposed of by the chemicals handling group. They currently generate 1500 polyethylene bottles as chemical waste each day. Most of these bottles are being sold to a Dallas manufacturer of acids for $0.01 a piece. Those which cannot be sold are incinerated. Waste steel drums are being sold to refurbishing operations where they are cleaned, usually utilizing a waste stream generated by the firm, and then returned to various chemical manufacturers for their use. Very few chemicals are received in glass bottles or paper containers. The wastes from this type of packaging material are either incinerated or disposed of by private contractors. Considering that management has not taken an active interest in the recycle or disposal of waste generated by its plant, it is amazing that the employees have succeeded in recycling and segregating as much of the waste as they have.

The budget under which the operation was carried out could at best be described as minimal if not really nonexistent. Talks with the managers about a classification system for industrial waste were held, one was especially interested in any such classification. He felt that if he could have information about the composition of chemicals in waste streams and information concerning the processes used by other companies, he would be able to determine to whom he could sell wastes and from whom he could buy wastes for use in his own operation. Both men felt they could give an accurate breakdown of waste generating practices along any lines which they were asked. Since the firm does segregate a large amount of its waste, they felt it would be very easy for them to give the composition of various waste streams that are generated. From observations of the operation, it would be a very easy procedure to provide them with instructions for filling out a questionnaire concerning the classification system. For most of the solid waste, all that is required is an analysis of the contents of the various dumpsters located on the site, and for the chemical waste, the firm already segregates these in various tanks and drums located in the special chemical handling area of the plant. They felt that a classification system would have a lot of users and offered to provide any further help that might be required.

## Industry No. 3679 -- Glass-Metal Seals -- Massachusetts

Glass-metal seals are components which are mostly used in the electronics industry. They are used also in vacuum technology, etc. The following information was obtained on a site visit to a rather small manufacturer.

| Steps | Materials Used and Remarks | Waste Generated |
|---|---|---|
| Receiving | a. Metal parts: Nickel-cobalt and nickel-iron wire, metal disks, copper parts, brazing materials, etc.<br>b. Glass preforms: tubes, beads, plates | Packaging Waste (cardboard, paper) |
| Cleaning | Methanol, and etching aids; Hydrogen reduction | Spilled acid<br>Defective parts (as received) |
| Assembly<br>Weld | | Rejects, bent wires, cut-offs, damaged graphite jigs, scrap welding rod, etc. |
| Seal | Furnace Operation | Rejects of assemblies |
| Plate | Plating Waste | |
| Test | | Rejects |
| Ship | | |

While some of the materials are high in unit cost, the amount of scrap generated does not, as a rule, encourage scrap separation, Disposal is as unsegregated solid scrap.

## Industry No. 3679 -- Printed Circuits -- California (91749)

The Company visited employs 400-500 people in the production of printed circuits. Major processing steps in the manufacture of printed circuit boards are summarized in Figure 1. The principal wastes are:

Pumice Slurry - generated at a rate of 50 lbs/day; containerized and trucked to regional landfill daily.

Captured Particulate from Dust Collectors - less than 1/2 cu. yd/day; contains fiberglass-epoxy, polyester, and copper fines; trucked to regional landfill.

Trimmings - scrap board, copper (given to scrap dealer), lead-tin solder, traces of nickel, expoy glass, polyester, dram of phenolics, gold (recovered 1036 oz. in 1972).

Methylene Chloride - the solvent is distilled internally in a closed loop system; still bottoms go to an 1100 gal. mixed solvent steel tank, along with proprietary shippers (85% methylene chloride with surfactants). The tank is emptied about every four months and dumped.

1,1,1 Trichlorethane - pumped into a 2000 gal. tank and picked up by a reclaimer; 34,000 gal. of waste were produced in 1972.

Aqueous Effluent - goes to the municipal sewer; contains sodium chloride; calcium and potassium salts; traces of copper, magnesium, oil and grease, nickel and EDTA (ethylene diamine tetramine); Oaktite (an alkaline cleaner); and developer.

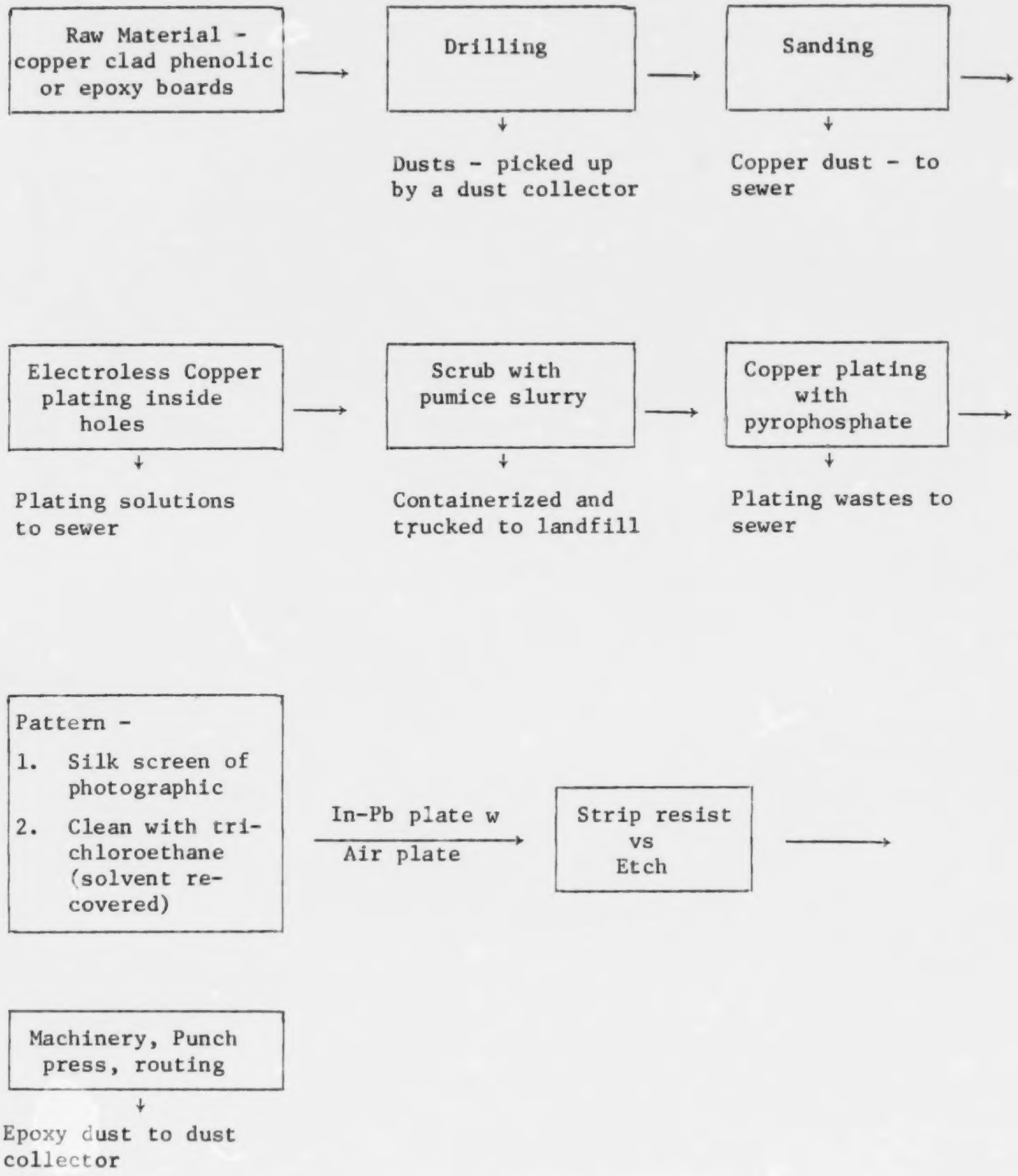
Hydrosqueegee Wastes - the Hydrosqueeger (HS) unit is used to fuse a level lead-tin solder. The usual waste, a dry sludge containing oil, dirt and bits of metal, is landfilled. When on occasion, a hot oil bath is used instead of the HS, the waste is drummed and trucked to landfill.

Obsolete Equipment - stored in a concrete platform and eventually removed by a junk dealer.

Plastic Sheet - mylar, polyolefin and plastic tape are used in quantity.

Approximately 30 cu. yds. of solid waste are collected and trucked to landfill each week. The Company recently found that their effluent water had 40 ppm Cu (40 lbs/day) which must be reduced to 2 ppm. They are in the process of putting in a pretreatment facility with a 300 gal/min capacity at a cost of $180,000. This facility will precipitate out the copper and thus produce a sludge for land disposal. The Company runs about 75 million gallons of waste per year.

Figure 1 : Major Steps in the Manufacture of Printed Circuit Boards


Raw Material - copper clad phenolic or epoxy boards
Drilling
Dusts - picked up by a dust collector
Sanding
Copper dust - to sewer
Electroless Copper plating inside holes
Plating solutions to sewer
Scrub with pumice slurry
Containerized and trucked to landfill
Copper plating with pyrophosphate
Plating wastes to sewer
Pattern -
1. Silk screen of photographic
2. Clean with trichloroethane (solvent recovered)
In-Pb plate w
Air plate
Strip resist vs Etch
Machinery, Punch press, routing
Epoxy dust to dust collector

## Industry No. 3691 -- Batteries -- Massachusetts

The firm is a $3 million/year specialty battery and mine cap lamp manufacturer. They also manufacture under contract for a Swedish conglomerate, and a U.S. battery plate operation. The following summarizes the solid waste management for both operations. The information was provided by the plant manager and is considered to be highly reliable.

Lead and lead oxide form the major solid waste problem. Metal scrap from the shops which do job-shop work to keep the personnel evenly employed is the second largest scrap generator. Overall, the firm buys about 1200 tons/year of lead and lead oxide of which about 30 tons/year are sent to National Lead Company for recycling. The plant is only a few years old and waste handling appears to be very good. Nevertheless, the situation can be regarded as typical for lead acid battery operations of all kinds. (Note: due to increased air-pollution control demands, fewer battery plants will do their own lead and lead oxide resmelting. Another firm reportedly discontinued some of its smelting operations and ship to National Lead for recycling.) The machine shop scrap operation is excellent. Generally, other than from packaging, solid waste consists mainly of a minor amount of floor sweepings.

### Plant Waste Disposal Flow Sheet

a. Receiving and Shipping
    Metal Scrap*...........Scrap Dealers
    Waste Paper............Contracted
    (Cardboard crates,
     etc.).................Waste
        to town dump.
        10 cu. yds/day
        uncompacted

b. Lead and Lead Oxide Plate Production

    Oxide Plates: Internal oxide recycling of part of oxide
        Acid waste is neutralized; goes to sewer
        Settling tank...effluent to sewer (2 mg/l. PbO)
            ...sulfate sludge in pit
            ...lead oxide in second settling tank.
               Periodically sent to National Lead
               for reclaiming.

    Lead Plates: Scrap internally recycled. Rejects to National Lead
        for reclaiming.

*See list of composition in attached table.

c. Battery Assembly Plant

Mostly assembled from parts bought from vendors
  Floor sweepings to dump collection
  Lead oxide dust from burning operation to an air settling pit

d. Machine Shop

99% of scrap (job scrap and captive shop) to scrap dealers
1% floor sweepings to dump collection

# Six Month Scrap Metal Record

## 3691 -- Batteries -- Massachusetts

| | |
|---|---|
| Steel Skeleton | 11,238 lbs. |
| Galvanized Punchings | 5,320 |
| Cast Iron | 1,760 |
| Aluminum Skeleton | 1,115 |
| Stainless Steel Skeleton | 4,049 |
| Aluminum Chips | 372 |
| Beryllium Skeleton | 181 |
| Brass Skeleton | 1,086 |
| Aluminum Alloy | 309 |
| Old Lead Plates | 1,859 |
| Steel Punchings | 1,410 |
| Galvanized Steel | 7,060 |
| Light Iron Galvanized Coil | 4,340 |
| Steel Scrap | 3,935 |
| | 44,034 lbs. |

## Industry No. 371 -- Automotive Plant With Paper Waste -- Michigan

A site visit was made to one automobile manufacturing plant and the information obtained was supplemented by discussions with corporate environmental personnel. The processing wastes typical of the automobile industry apparently include:

Rubber Wastes - tires and belting; waste from trim operations; moldings; etc. (Similar to rubber plant wastes.)

Plastic Wastes - scraps from trimming operations; moldings; and parts, including vinyls from seats, tops, and paddings; waste LEXAN headlight lenses. The company does its own injection moldings of dashboards, seat cushions (polyurethane foam), headlight and taillight lenses, and air filters.

Inert Solids - fly ash; foundry sand; weld slag; coke fines; cupola drops; floor sweepings. The cupola drops are large chunks of metal contaminated with slag. After pouring castings, such drops remain on the walls of the refractory brick.
Weld slag is a chipping waste generated in the manufacture of large parts.
Coke fines are powdered, activated carbon generated in foundry operations. They can be used as a fuel or lubricant.

Waste Oils - cutting and lubricating oils; skimmings from oil separation tanks; hydraulic turbine oil; automotive oil; drainings from crankcases; sulfur-free mineral oils used as coolants and in machining; Bunker C oil; #2 fuel oil with a red dye tracer.
Crankcase drainings contain all kinds of metals (e.g., Sn, Ti, Mo, Fe, etc.) which must be removed before burning. Clean oil is required to get acceptable nozzle life. The company is currently centrifuging to take out the heavy metals.
Scrap oil from waste water treatment plants is burned.
Cutting oil has quite a bit of sulfur and cannot be burned in a boiler.

Flammable Liquids - waste thinners, laquers, and varnishes (alternator coils are varnished.) These materials are either burned or reclaimed by Nelson Chemical in Detroit and reused.

| | | |
|---|---|---|
| Residues and Tars | - | drag out wastes; mill scale (removed rust); caustic salt bath; cyanide solids; residues from storage tanks (e.g., finely suspended particulate in oil tank that settles out over the years); tank farm drainings.<br>The caustic salt bath (80% NaOH) is used for cleaning painting hooks. All of the paint is stripped off, and the salt stripping compund is periodically discharged. It is solid and contains everything typically found in paint.<br>Cyanide salt from cyanide salt baths has to be drained periodically. The residue which is scraped out is tarry, much like asphalt. |
| Sludges | - | Wastewater Treatment Sludges - sludges from grit tanks, settling tanks or ponds, air flotation scums, oil separation tank bottoms.<br>Paint Sludges - sludge from spray booths. The booth has a water wall. Paint goes to the bottom of the sump. Chemicals are added to the water to "kill" the paint so that it is no longer gunky. However, paint particles do not settle well. The vacuum drum used to dry the sludge has springs on it. As they flex, the paint pigment falls off.<br>Oily Sludges - from polishing, fine grinding, and milling operations; they contain fuller's earth, metal and grinding compound and oil.<br>Water Treatment Sludge - e.g., calcium carbonate sludge from process water treatment with cold lime or zeolite. The lime may be used to bring up the pH of water.<br>Metal Hydroxide Sludge - from plating.<br>Foundry Scrubber Sludge - the sludge gets mixed up with sluicing compunds and binders which contain phenol. |
| Miscellaneous | - | Wire drums - crysyllic acid is used for cleaning and the drums are shipped to a reclaimer.<br>Parts Division -<br>1. Cans of returned chemicals without labels and unmarked cans or drums of off-grade liquids or aerosols are particularly difficult to handle.<br>2. Obsolescent, off-grade, or scrapped parts.<br>3. Used machinery and equipment (e.g., dies). |

Radioactive material - used for tracers in some plants or for experimental purposes. The primary metal waste in the automobile industry are copper, zinc, and iron. The waste water treatment plant for plating wastes generates 75 tons/day of sludge.

Plans include a changing over from cupolas to electric arc melting in order to eliminate an air pollution problem, very evident in the plant visited. In addition four heat recovery boilers are being installed, this being the most economical way to deal with paper wastes. Apparently the minimum volume for recycling of paper is 5000-6000 tons/year.

| | |
|---|---|
| Spent Chemicals | - these are generally acid solutions containing heavy metals, and might include copper etchants chromatic conversion coating wastes, plating wastes, etc.<br>Sump pump sludge - this sludge typically contains chromium, copper iron; traces of gold, silver, cadmium and nickel; an inert deburring compound; polyelectrolytes; and an aluminum coagulant. It is sent to a Class I dump site.<br>Toxic and dangerous chemicals - these are primarily laboratory wastes and are produced in small quantities. They are generally stored in 30 gallon drums and hauled to Nevada for disposal. The kind of wastes generated include: bottles of boron tribromide, gallium arsenide slurries; arsenic compounds, phosphorous oxychloride; cyanides; beryllium and beryllium oxide; tubes containing mercury vapor; broken glass and swabs contaminated with toxic chemicals.<br>Reclaimed solvents - methylene chloride; trichloroethane; perchloroethylene.<br>Machine shop turnings - aluminum, iron and precious metals (kept separate for sale).<br>Sheet metal scrap - all aluminum |
| Obsolete Equipment | - sold or dumped; rejected transformers are sold as copper scrap. |
| Paint Booth Wastes | - paint is skimmed off and discarded with the general trash; alkaline effluent goes to the sanitary sewer; scrubbers remove arsnic, phosphine, acid fumes, and solvents. |

### Industry No. 3825 -- Electronics and Electroplating -- California (94304)

The company visited employs 22,000 people, and generates a variety of wastes, many similar to those produced in printed circuit board manufacture (cf. 3679). Specific waste streams discussed include:

| | |
|---|---|
| Spent Solvents (mixed) | - these are containerized and trucked to landfill. They typically contain alcohols (2-propanol, methanol, ethanol); aliphatic hydrocarbons (Stoddard solvent, laquer diluent, photoresist thinner, etc.); traces of aromatics (toluene and benzene derivates); culting oils; halogenated hydrocarbons; methyl ethyl ketone; acetone; paints and photoresist. They cannot be reclaimed because they contain sulfur. Cost of disposal is 7.5-16¢/gallon. |
| Electronics Instrument Scrap (e.g., off-quality circuit boards) | - often donated to schools. |

## Industry No. 3861 -- Photographic Film and Cameras -- Massachusetts

Although a site visit was requested through one of the operating divisions, the appointment set up was with the public relations department. The discussion of solid waste management practice in the plants was of necessity fairly general and qualitative, since the company considers the exact composition of the solid and liquid wastes generated to be highly proprietary.

One film division having eight buildings was described. Two of the buildings coat paper; two produce pack film; two are chemical buildings, and one is a negative research laboratory. The total waste amounts to about 600 ton/month. The principal waste is plastic coated papers. Many thousand pounds per day are generated and no good technology exists for recycling. The paper, which is very fine, might typically be coated with 8-10 layers of plastic. There is some pure plastic waste from film manufacture which can be chopped up and recycled. Rejected film is sent out for reclamation of silver. Rejected film packs are sent to a hospital where the patients pull the packs apart and separate lead pods, metal, and negatives. The lead pods are resmelted. Organic and inorganic waste solvents are generated, but their chemical composition is a secret. They are either handled in one of two solvent burners or hauled to landfill by a private contractor.

Divisions that manufacture cameras and sunglass lenses generate plastic and metal wastes that are considered so highly proprietary that they are chopped up very carefully for security reasons and taken to a private dump site which is closely regulated by the company. Cryolar, acrylic and styrene wastes are generated in substantial quantities. Numbers were written on a blackboard, but we were requested not to quote them. A new product uses a battery which has a small quantity of mercury. Rejects are packaged into plastic drums and put into the highest layer of landfill over two feet of diatomaceous earth.

We were given to believe that the company works closely with the State and the owner of the landfill to develop and assure proper waste handling procedures. We were told that the State has been given data on waste composition on a confidential basis.

## Industry No. 4953 -- Waste Disposal Plant -- Texas

This firm, now defunct, tried to develop a business out of processing industrial waste on a "nuisance free" basis. They worked under the premise that very few companies have sufficient total volume to set up facilities of their own economically. According to the files, to which we were given access, many companies in the Southwest were contacted to assess disposal needs and interest in a central incineration facility. As a result of this sales effort, some information was obtained, as summarized below, on solid and liquid wastes generated by a number of companies.

### Acetylene Manufacturing Wastes

1. Quench water contains 600-800 ppm of suspended carbon solids.
2. Carbon soot wastes are semi-solid and contain 80% moisture, 1% ash, and 19% combustibles with a heat content of 12,000 ± 2000 BTU/lb.

### Vinylchloride Monomer (VCM) Waste (80 T/mo.)

| | |
|---|---|
| Moisture | 0 ± 1% |
| Ash | 0 ± 1% |
| Combustibles | 100 ± 2% |
| BTU/lb combustible | 10,000 ± 2000 |
| % Cl | 63 ∓ 5% |
| Form liquid | |

### Waste Oil (250 T/mo.)

| | |
|---|---|
| Moisture | 1 ± 1% |
| Ash | 0.1 ± 0.1% |
| Combustibles | 98.9 ± 1.1% |
| BTU/lb Comb. | 17,500 ± 2000 |
| S | 0.5 ± 0.2% |
| Form liquid (still bottoms) | |

### Methanol Manufacturing Waste (220 T/mo.)

| | |
|---|---|
| Moisture | 12.5 ± 2% |
| Combustibles | 87.5 ± 2% |
| BTU/lb comb. | 10,000 ± 2000 |
| Form liquid (methanol tails) | |

One of the most difficult wastes to handle is carbon cake from acetylene manufacturing. Is is apparently almost impossible to recover filter cake that has been used for removal of acetylenic carbon. The problem is that the carbon is graphitic and does not burn well below 1600 - 1800°F. At those temperatures, diatomaceous earth tends to fuse, making it useless as a filter. Current waste disposal costs are about $500,000/year.

Typical waste strength generated in the manufacture of organic chemicals include: non-aqueous liquid wastes, generated at a rate of 150-200 T/mo; off-spec carbon black; combustible chlorocarbon with a halogen content of 60-80%; tank bottoms, wet alcohol, and filter cake.

A sales trip was made to a Midwest location covering the following kinds of companies:

Paint - waste thinners

Steel - liquid wastes

Airlines - crankcase oils, jet fuels, and paint sludge

Organic Chemicals - produces a waste which is 72% chlorine, 18% organics, and 10% $FeCl_3$ solids.

Chemicals - reported 140 T/mo. of filter cake, 20 T/mo of still bottoms, 100 T/mo. of waste tar, and 2000 T/mo. of ammonium sulfate solution.

Refinery - produces 1 T/day of API separator sludge containing 80% moisture; 18 T/day of clarifier sludge with 80% moisture; and 4.5 T/day of BOD sludge with 90% moisture

Chemicals - has mountains of gypsum piled up. The company uses refinery sludge as feedstock and produces sulfuric acid

Chemicals - waste filter cake and polyvinyl chloride

Chemicals - generated 120 T/mo. of filter cake slurry, a liquid waste having 50% combustibles, 50% ash, and a BTU content of 8000/lb of combustible

Plastics - must dispose of atactic polypropylene, solid separator polypropylene, and butyl scrap

Oil Refinery - generates at least 42 different wastes - various types of tank bottoms, off-spec products, separation fluids, dredgings, trash, garbage, and skimming. There is a heavily aromatic liquid outfall with a temperature of 120-130°F. The outfall from the API separator is a colloidal suspension of rubber fines and crude oil.

Petrochemicals - has a furfural-butadiene waste

Petrochemicals - generates beta-chloropropine as a waste from allyl chloride manufacture. The material has no water and is liquid at 40 psi.

Several wastes for deep well disposal were identified as:

Coke plant liquors
Process brines
Caustic scrubber effluents
Acid wastes
Phenolic and chlorophenolic solns
Refinery catalytic drum distillate

## Industry No. 4953 -- Waste Disposal Firm -- Massachusetts

This company has been expanding rapidly by buying smaller outfits across the country. They provide solid waste management services to approximately 28,000 commercial, industrial, institutional, and municipal customers. The services include storage, collection, processing, and recovery or disposal of solid and liquid wastes.

They offer services to companies such as steel mills. In this case, they pick up liquid pickling acid wastes and dispose of them in lagoons that are formed from old strip mines in Pennsylvania. They use tank trucks for hauling and the product is neutralized with lime. They charge 8¢/gal. for this service. Other locations under consideration as disposal sites are in Ohio and New Jersey.

In one of their operations, where they collect municipal refuse (they consider themselves a leader in this field), they salvage corrugated board at the transfer stations using hand separation and the waste is baled. They are keeping a close eye on the hazardous waste area as a business opportunity because they believe that the government will be pushing industry to resolve this problem in the near future. They are currently working with a city which is considering the possibility of closing its incinerator, and have offered to transfer the city wastes a distance of 35 miles to a private landfill site at a cost of $5/ton.

Industry No. 7399 -- Solvent Recovery Plant -- New Jersey

The company only accepts wastes which can be recovered, and they then return the recovered material to the original company. They deal primarily in solvents and distillable organics. The basic technology is distillation, including vacuum and high purity distillation. Companies will only send wastes when the solvent is sufficiently valuable to recover. This is entirely a matter of economics. If the solvent sells for 25¢ a pound, and waste disposal costs are 10¢ a pound, then a company can afford 35¢/lb. to recycle. The industries serviced include organic coatings, plastic coatings, metal finishing, pharmaceuticals, electronics and chemicals.

Some of the properties which determine the technical feasibility of solvent recovery were discussed. Isopropanol, for example, cannot be recovered due to the azeotrope. It is important to know the nature of any contaminants -- e.g., light oil in vapor degreasing solvents, PVC, paint. It is also important to know the nature of the reuse in order to determine whether the high purity recovery facility should be used. The company has seven stills for different functions. The manager suggested that our Classification System must take into account mixtures of solvents, giving at least the primary and secondary components. He has found that each customer's waste must be batched separately. If one customer sends acetone contaminated with methanol and another sends acetone contaminated with toluol, the wastes are really essentially different.

In general, the properties determining solvent recovery are geared to processing difficulties. Specific gravity, yield, pH, and non-volatile residue are some of these properties.

The firm is taking butanol, methylene chloride, and water generated in the manufacture of penicillin, recovering to specifications and returning the solvents to the manufacturer. It actually costs more to do this than for the manufacturer to go it alone, but pharmaceuticals have such a limited lifetime that the manufacturer prefers to go outside.

The composition of the wastes received must be known in some detail. "Organics contaminated with metals" is insufficient information, for example. Mercury biocides are used in organic coatings. Color stabilizers, cadmium, or lead components must be identified.

The kinds of problems that can be encountered in recovery may be illustrated by a company which generates acetone, tetrachloroethylene, methyl chloroform, Freon, and trichloroethylene wastes. Each solvent is used separately, and the process effluent comes out separately. The company, however, puts all the waste solvents into one drum.

There is, of course, a solid waste problem associated with solvents recovery itself. When chlorinated hydrocarbons are recovered, the residue is a low chlorine oil which is either burned or dumped. Still bottoms are generally dumped. The solid waste from paint solvent recovery is a real "goo", with a consistency something like peanut butter. This type of waste, which is not at all uncommon, cannot be handled in an incinerator. 1, 1, 1 - Trichloroethylene is recovered from an automotive maintenance plant. It is distilled to around 200°C, and the residue has a solids content of from 0 to 50%. Rags, shoes, and balls from ball-milling operations are unwelcome contaminants seen occasionally.

The minimum quantities of material that can be accepted for reclamation are 2 drums of fluorinated solvents, and 30,000 gallons for fractional distillation. One factor discouraging oil recovery is that reclaimed oil pays the same tax as new oil. The company visited also runs an incinerator in Connecticut, and finds that it is quite a problem to get uniformity of feed, when BTU content as well as viscosity vary all the time.

## Industry No. 7329 -- Management Consulting Offices -- Massachusetts

The project team toured the waste handling facilities in our own company. Although the principal solid wastes generated at ADL are office, cafeteria, and packaging wastes, none of which are of primary interest under the program, the handling practice points up a problem of fairly universal importance. Office wastes are collected every evening by the facilities staff. They are spread out on a conveyor belt, and non-paper wastes (can, plastic cups, apple cores, etc.) are removed by hand. For security reasons, the paper wastes are hydropulped. Excess waste is pressed out of the pulp and recycled, and the pulp, together with all other wastes is put into a 7 cu. yd. dumpster, from which it is collected by a contractor and taken to a landfill. The pulped paper, which is quite pure and potentially recyclable is in fact not sold as scrap due to the relatively small volume produced.

## Industry No. 8911 -- Chemical Construction Company -- Missouri

The offices visited do much of the design in engineering work for company projects and paper is, therefore, the largest single waste generated. Since there are no cafeteria facilities in the offices, there is a minimal amount of food waste to be disposed of. Any such waste comes from the vending machines located in the basement of the company.

The waste handling practices of the company are relatively unsophisticated. Each evening janitors empty the trash baskets in all the offices and conference rooms. Any documents which are potentially secret are taken to a shredder prior to disposal. This shredder is located in the basement and the person wishing to dispose of a document has the responsibility for taking it to the shredder. The contents from the shredder are then mixed in with the general waste. All waste is carried to a large dumpster located at the back of the plant. This dumpster is picked up every other day by a private contractor who carries its contents to a local landfill. They previously had separated paper waste from any noncombustible waste that might have been present and incinerated the paper waste. Air pollution regulations, however, forced them to cease incineration and to seek alternative means for disposal of their solid wastes.

## INTERVIEWS WITH MISCELLANEOUS INDUSTRIES, ASSOCIATIONS, AND GOVERNMENT REPRESENTATIVES

### Interview with Bob Shultz of the Solid Waste Office of Connecticut and Ken Jenkins of G.E.

ADL Personnel talked to Shultz only briefly since most of the solid waste planning work for the state has been done under contract with G.E. Ken Jenkins of G.E. reviewed their role in the Connecticut program briefly.

After an initial industrial waste survey, G.E. decided to focus on four categories of problem wastes:

Spent Solvents

Metal hydroxide sludges

Waste oils -- cutting and auto. lube

Chemical milling wastes (from electrochemical machining, mainly from United Aircraft)

The next step was to interview some of the bigger manufacturers in Connecticut and to try to develop multipliers. Bureau of Labor Statistics data and Texas multipliers were used to get a list of manufacturers. The interviewing was done by a consultant -- Ken Lanouette, of Industrial Pollution Control, Westport, Connecticut 06880. Following the interviews, Lanouette developed a set of multipliers for Connecticut, going back to the Bureau of Labor Statistics figures. The Connecticut multipliers turned out to be quite different from those generated in Texas.

G.E. has had difficulty in coming up with recommendations for handling problem wastes. The best they can suggest is that the wastes be encapsulated and put into a special landfill. The best schemes for energy recovery seem to involve teaming up with utilities. However, heavy metal impurities represent problems for utility boilers, and by and large the utilities are reluctant to take a chance.

### Interview with Don Andres, California State Department of Health, Sacramento, California

A solid waste management program had just been approved for the State of California at the time of the interview (June, 1973). Until then dumps had been regulated on the basis of potential water quality problems.

California has given considerable thought to industrial solid wastes. Four or five years ago, the State projected industrial waste trends. They found a better correlation with employment than with value added, particularly for seasonal industries. The Northern Section of the Manufacturing Chemists' Association, National Canners and a number of other trade associations cooperated in the initial waste projections.

California's concern with solid waste management, as well as aspects of environmental pollution has attracted a number of waste disposal companies. Browning-Ferris is very active. Rollins-Purle has visited and is considering becoming heavily involved in the State.

Incineration is virtually impossible in California due to the very stringent air pollution standards in the L.A. area. If present air quality standards can be met, it is likely that permissible effluent emissions will be reduced still further. The State is interested in pyrolysis, however.

There have been accidents due to inadvertent mixing of incompatible chemicals in Class I landfill sites. At the Antioch site, acids were thrown into a pit. Solvents were added and caught fire. When the fire was put out, drums containing beryliium wastes were found nearby. It was feared that they might have ruptured, although on further inspection, it turned out that they had not. The dumping of magnesium fines used to cause lots of landfill fires. Then a market was found for the fines, and the problem was happily eliminated.

Waste wood chips brought the paper industry to California. Large quantities of chips are shipped to Japan for paper manufacture. Garden State Fiber is now claiming that they can't get enough scrap paper. However, they want to pick up the scrap at the point where they sell their papers so that their trucks don't have to come back empty.

## Interview with National Solid Waste Management Association, Washington, D.C.

ADL representatives met with the new technical director, James Greco, and the director of the Association, Mr. Wingerter. This association has 140 members who are manufacturers of treatment and disposal equipment (shredders, balers, etc.) and who are contractors and operators handling the collection of industrial, commercial, and domestic refuse. Some are also involved in salvage and containerization.

Greco and Wingerter were very interested in our EPA study and offered their assistance. For example, if we developed a suitable classification system, they would mail it to appropriate members for comment. They have an Industrial Waste Council which will be meeting in the spring. If we would like, we could discuss the study at the meeting.

During the discussion, the following properties were judged to be significant to the collector/disposer:

1. Compactibility
2. % combustibles
3. Physical forms or configuration
4. % ferrous metal
5. % corrugated
6. Moisture content
7. Hazardous
8. Corrosive

It was pointed out that properties such as 4 and 5 may suggest to the collector/disposer that he could develop a successful salvage business.

We also discussed whether there was any need to identify the industry source in the code. After considerable discussion, we thought that this could more easily be handled by merely relating the SIC index to the SW (solid waste) index.

## Interview with Howard Ness of NASMI (National Association of Secondary Materials Industries)

Howard Ness had previously sent us, NASMI's Standard Classification for Non-Ferrous Scrap Metals, Paper Stock, Cotton, Synthetics and Wool. A circular will be issued in 1973 on shredded cans. As far as NASMI is concerned, there is no need to classify any other wastes since they are not marketable. Nobody deals in glass cullet now. There is no market for plastics. There is even little use for textile wastes. The mixed and synthetic textile fibers are difficult to recycle, and the market for natural fiber (cotton and wool) is generally very small.

NASMI has Specification Committees for paper, textile, aluminum, zinc, etc. wastes. Specifications are written and periodically revised in response to the market. Both buyers and sellers of scrap are represented. NASMI has not yet gotten into liquid wastes.

Ness was very skeptical about the value of a generalized classification system to secondary materials dealers. He does not anticipate that any companies, except perhaps many small ones, will report on wastes that in fact gold mines. He did think we should incorporate a "Marketability Index" into our Classification System. He would be happy to assist us with such indexing. We might look at the American Metal Market and the Official Board Market to get a feeling for scrap needs.

### Interview with John Hanley, Arthur D. Little, Inc., Cambridge, Massachusetts

Project team members talked to John Hanley, Comptroller of our Company, concerning the gathering of information about the solid waste generating characteristics of various industries. He felt that, in most instances, the comptroller would be the person in the corporate structure who would be able to fill out questions about a company's waste generating practice.

The general procedure that a comptroller in a large company would follow to get the information requested would be as follows:

Upon receipt of the questionnaire, each of the division comptrollers would be sent a request to reply to the questions that relate to the waste generating characteristics of their specific division. In addition, the cost accounting comptroller would be contacted for information concerning the costs of waste disposal and the revenues that were being earned from the sale of any refuse. In a small organization, all these functions would be performed by one individual.

The following are the types of information that the comptroller could readily provide:

Waste Generated (types and quantities)

Degree of Separation or Segregation Practiced by the Company

Methods of Disposal Being Utilized

Special Problems Arising with the Handling of the Waste

Cost of Waste Disposal

Revenues Earned by the Sale of any Wastes Generated

Questions relating to specific chemical or physical properties of the wastes generated would be beyond the scope of information readily available to the comptroller. Most people in the accounting office would consider it far too difficult to get such information, and in general they would not do it.

In short, it seems that the comptroller for a manufacturing company has access to more information than we had initially anticipated. However, for a complete description of solid waste management practice it would probably be necessary to obtain information from both the plant manager and the accounting office.

## Industry No. 3325 Interview Meeting with Committee Members

The ADL project director met with the following members of a Steel Industry Committee concerned with environmental control in the industry:

1. DeYarman Wallace, Director of Environmental Control
   Youngstown Sheet and Tube Company
   Youngstown, Ohio
   Tel: 216-755-1411, X627

2. David G. Boltz, Solid Waste Control Engineer
   Bethlehem Steel Company
   Bethlehem, Pennsylvania 18016
   Tel: 215-694-2721

3. John O. Hawthorne, Senior Research Chemist
   U.S. Steel Company
   125 Jamison Lane
   Monroeville, Pennsylvania 15146
   Tel: 412-351-3100

4. John C. Hogan, Senior Research Chemist
   Armco Steel Company
   Middletown, Ohio 45042
   Tel: 513-425-2789

The meeting was held in the U.S. Steel Building at 600 Grant Street in Pittsburgh, Pennsylvania. The Committee liked the backward form better than the forward. However, they thought that annual operating costs and % AOC as labor would be hard to get. In fact, there would be considerable resistance to giving dollar figures at all. Furthermore, water and gas data have already been submitted to the EPA. There would be a lot of resistance to repeating it.

Secondary and Scrap Materials Utilization is a long and complicated story for the steel industry. They distinguish between prompt industrial scrap and obsolete industrial scrap. It was thought that individual plants could supply very little data not available from other sources. We might add a note on our form to the effect: If the information is available elsewhere, give reference. It would simplify matters considerably if we would state explicitly: "Omit waste treatment processes when the end product is used within the plant."

A large part of the steel industry wastes would fall into the category of "other inerts." The principal wastes are slag and BOF flue dust or fines, now removed by electrostatic precipitators, scrubbers, and bag houses. The dust is somewhat difficult to handle; it doesn't agglomerate well. Furthermore, there is some reluctance to dispose of it, since the iron might someday be recovered. It is thrown in the ground on site in many places. Sludges represent another major problem (pretreatment sewage sludges).

## MAJOR CORPORATION 27 SOLID WASTE MANAGEMENT IN THE PRINTING AND PUBLISHING INDUSTRY

### Interview with Battelle Memorial Institute - Rufus Short (Telephone)

Battelle had completed a study of solid waste in the industry. Their report contains a great deal of detailed information on quantities of waste, but relatively little on physical-chemical properties. The data, according to Short, were plentiful but highly varied and from a statistical standpoint this dispersion in the data made it somewhat difficult to arrive at clearcut conclusions. Short feels that the printing and publishing industry is a tidy one, recycling and finding as much use for its solid waste as possible. He remarked that printing plate lead, in particular, is carefully salvaged and reused. Even the slag which collects on the melted lead is carefully handled.

While he could not say too much because he hasn't seen an industrial solid waste classification system, Short felt that such a system could be useful.

# CHAPTER VII. DISCUSSION

## I. PARTIAL DEMONSTRATION OF THE CLASSIFICATION SYSTEM

Table I summarizes much of the information obtained from the field interviews and site visits. In each case, reported materials were classified, together with the delivery code (receiving entity), the final disposal codes, and the hazard codes. In no case should the waste materials indicated be considered a comprehensive accounting. In some cases, the designated SIC sector will have many kinds of manufacturing plants producing distinct waste materials and quantities. The information on Table I contains only that segment of the four-digit industry that we happened to interview. Thus, it is not necessarily representative. The Table does demonstrate, however, how readily complex industrial waste information can be sorted in a coherent manner. Column 4 of the Table, for example, can very quickly be scanned locate industries producing inorganic and organic chemical wastes (code numbers 82000 and 81000 ) which in most cases will be hazardous.

## TABLE I

## PARTIAL CLASSIFICATION OF SELECTED INDUSTRIAL WASTES BASED UPON INTERVIEWS

| SIC | Industry Description | Major Waste Materials | IWC Material Codes | Delivery Codes | Final Disposal Codes | Hazard Codes |
|---|---|---|---|---|---|---|
| 0211 | Feedlots | Manure | 63001 | 12 | 01,04,20 | 03,13 |
| | | Bedding Material | 70900 | 12 | 01,04,20 | 03,13 |
| 0241 | Dairies | Ground Cover | 51019 | 12 | 01 | -- |
| | | | 52219 | 12 | 01 | -- |
| | | Carcasses | 65000 | 12 | 01 | 03,13 |
| 2011 | Meat Packing | Manure | 63001 | 01 | 12 | 03 |
| | | Viscera | 61001 | 09 | 09,04 | 03,13 |
| | | Bone | 61002 | 09 | 09,04 | 03,13 |
| | | Other | 61019 | 09 | 09,04 | 03,13 |
| 2044 | Rice Miller | Rice Hulls | 70103 | 02 | 01&20 | -- |
| 2281 | Textile Plant | Synthetic Fibers | 42000 | 10&11 | 09 | -- |
| 2282 | Yarn Plant | Natural Fibers | 41000 | 10&11 | 09 | -- |
| 2285 | Weaving Mills | Blends | 43000 | 10,11&12 | 05&09 | -- |
| 2295 | Impregnator | Papers | 32001 | 01 | 01 | -- |
| | | Fiberglass | 41005 | 01 | 01 | -- |
| | | Epoxy | 22006 | 01 | 01 | -- |
| | | Polyethylene | 43002 | 01 | 01 | -- |
| | | Rugs | 41001 | 01 | 01 | -- |
| | | Phenols | 81029 | 09 | 01 | 09,10,12 |
| | | Ketones | 81021 | 09 | 01 | 09,10,12 |
| | | Other Chemicals | 81--- | 09 | 01 | 09,10,12 |
| 2361 | Linerboard Mfg. | Wood | 31001 | 12 | 04,20 | 0 |
| | | Bulk | 31002 | 12 | 04,20 | 0 |
| | | Pulp | 31003 | 12 | 12 | -- |
| | | Black Liquor | 81--- | 12 | 04 | 12,13 |
| 2833<br>2834 | Chemical Plants | Very complex mixtures | | | | |
| | | Various organic chemicals | 81--- | 12 | 05 | 03,09,10,12 |
| | | Pharmaceuticals | 83005 | 12 | 05 | 03,09,10,12 |

| SIC | Industry Description | Major Waste Materials | IWC Material Codes | Delivery Codes | Final Disposal Codes | Hazard Codes |
|---|---|---|---|---|---|---|
| 2851 | Paint Mfgr. | Paints | 83003 | 09 | 01 | 09,10,11 |
| | | Various Inorganics | 82--- | 09 | 01 | 09,10,11 |
| | | Various Organics | 81--- | 09 | 01 | 09,10,11 |
| 2869 | Solvent Recovery | Various Organics | 81--- | 12 | 01&05 | 10,12 |
| 2911 | Oil Refinery | Very complex chemical Mixtures | 81---<br>82--- | 09,11&12<br>09,11&12 | 05,09<br>16,19 | Most Hazards Represented |
| 3079 | Monomer Production | Polystyrene | 21004 | 09 | 01,09 | -- |
| | | Papers | 32001 | 09 | 01 | -- |
| | | Rubber | 23019 | 09 | 01 | -- |
| | | Glass | 52100 | 09 | 01 | -- |
| 3111 | Tanners | Leather Scraps | 61008 | 11 | 20 | -- |
| | | Leather Shavings | 61008 | 01 | 01 | -- |
| | | Tanning Liquid | 81--- | 12 | 12 | 12,13 |
| | | Treatment Sludge | 84102<br>81---<br>82--- | 01 | 01 | 12,13 |
| 3229 | Fiberglass Mfr. | Paper | 33022 | | | |
| | | Iron | 11211 | | | |
| | | Ceramic | 52201 | | | |
| | | Fiberglass | 41005 | | | |
| | | Organic Chemicals | 81--- | | | |
| 3334 | Aluminum Smelters | Copper | 12102 | 12 | 09 | -- |
| | | Slag | 52301 | 12 | 01 | 13 |
| | | Aluminum | 12101 | 12 | 09 | -- |
| | | Organics | 81--- | 12 | | |
| | | Inorganics | 82--- | 12 | | |
| 3519 | Tractor Engines | Misc. Iron | 12111 | 10 | 09 | -- |
| | | Aluminum | 12101 | 10 | 09 | -- |
| | | Zinc | 12104 | 10 | 09 | -- |
| 3523 | Tractor Plant | Carbon Steel | 11212 | 10 | 09 | -- |
| | | Misc. Iron | 11211 | 10 | 09 | -- |
| 3585 | Air Conditioners | Sheet Metal | 11211 | 10 | 09 | -- |
| | | Vinyl Sheet | 21001 | 10 | 09 | -- |
| | | Styrene | 21004 | 10 | 09 | -- |
| | | Fiberglass | 41005 | 09 | 01 | -- |
| | | Zinc dyecastings | 12104 | 10 | 09 | -- |
| | | Aluminum tubes | 12101 | 10 | 09 | -- |
| | | Copper tubes | 12102 | 10 | 09 | -- |

| SIC | Industry Description | Major Waste Materials | IWC Material Codes | Delivery Codes | Final Disposal Codes | Hazard Codes |
|---|---|---|---|---|---|---|
| 3679 | Printed Circuits | Nickel-Cobalt | 12214 | 10 | 09 | -- |
| | | Iron | 11211 | 10 | 09 | -- |
| | | Copper | 12102 | 10 | 09 | -- |
| | | Glass | 52100 | 01 | 01 | -- |
| | | Ashes | 52303 | 01 | 01 | -- |
| | | Methonol | 51014 | 01 | 12 | 08 |
| | | Trichlroethane | 51012 | 12 | | 19,10,12 |
| | | Several other waste materials | | | | |
| 3691 | Batteries and Lamps | Steel | 11212 | 10 | 09 | -- |
| | | Zinc | 12104 | 10 | 09 | -- |
| | | Aluminum | 12101 | 10 | 09 | -- |
| | | Stainless | 11213 | 10 | 09 | -- |
| | | Iron | 11211 | 10 | 09 | -- |
| | | Beryllium | 12117 | 10 | 09 | -- |
| | | Brass | 12201 | 10 | 09 | -- |
| | | Lead | 12103 | 10 | 09 | -- |
| | | Misc. Inorganics | 82--- | 01 | 11 | 09,10 |
| 371 | Auto Mfgs. | Rubber Tires | 23001 | | | |
| | | Rubber Belts | 23006 | | | |
| | | Plastics-Vinyl | 21001 | | | |
| | | Plastics-Urethane | 22004 | | | |
| | | Inerts-Ashes | 52302<br>52303 | | | |
| | | -Slags | 52301 | | | |
| | | Spent Oils | 53010 | 12 | 05 | 08,12 |
| | | Traces:Selenium | 12122 | 12 | 05 | 08,12 |
| | | Traces:Titanium | 12111 | 12 | 05 | 08,12 |
| | | Traces:Molybdenum | 12120 | 12 | 05 | 08,12 |
| | | and others | | 12 | 05 | 08,12 |
| | | Solvents | 83008 | 10,12 | 05,09 | 08,13 |
| | | Misc. Tars | 81--- | 09,10 | 09,16,01,19 | 04,12 |
| | | Inorganic Residues | 82--- | 09,10 | 09,16,01,19 | 04,10,12 |
| | | Conventional Sludges | 8410<br>84201 | 12<br>12 | 19<br>19 | 07,08,09,10,1<br>&12 |
| | | Paint Sludge | 81--- | 12 | 19 | " |
| | | Oily Sludge | 82--- | 12 | 19 | " |
| | | Plating Sludges | 82--- | 12 | 19 | " |
| | | Foundry Sludges | 82--- | 12 | 19 | " |
| 3825 | Microwave Equipment | Similar to 3679 | | | | |

| SIC | Industry Description | Major Waste Materials | IWC Material Codes | Delivery Codes | Final Disposal Codes | Hazard Codes |
|---|---|---|---|---|---|---|
| 3861 | Photographic Film | Complex Organics | 81--- | 12 | 05,09 | 10 |
| | | Inorganics | 82--- | 12 | 05,09 | 10 |
| 4953 | Waste Treatment Services | Varies | Varies | Varies | Varies | Varies |
| 5411 | Chemical Consulting Co. Office | Office Wastes | 92000 | | | -- |
| 7329 | Consulting Office | Office Wastes | 92000 | 09 | 01 | -- |
| | | Cafeteria Wastes | 91000 | 09 | 01 | -- |

## II. STATISTICAL REPORTING OF INVENTORY RESULTS

The inventory forms offer many combinations of possibilities for statistical reporting summaries. Clearly, it would be impractical to publish for wide distribution all possible statistical results. Thus, if an inventory program is implemented, two types of information retrieval are envisioned:

(1) A standard statistical summary volume(s) for wide distribution. This reference would be deisgned for use by government officials at all levels concerned with policies, planning, and economic aspects of industrial waste management. It would also serve the needs of private industrial users in the performance of market studies for treatment equipment or feasibility studies of value recovery systems.

(2) Tailored information retrieval in response to special requests, providing levels of detailed information not contained in the standard statistical reference. Users of this system would include State level pollution monitoring and surveillance agencies and any variety of researchers in the public or private sector with more detailed information requirements.

This first form of information retrieval, by design, is very general and presents aggregate statistics in a manner that precludes the identification of any particular firm or plant. The second would have the capability of ultimately retrieving information in primary form, as reported on the inventory form. Because of the design of the inventory form, it will be possible to retrieve a waste processing flow chart for each industry reporting. The issue of confidentiality of information, and rules for retrieval of certain types of information, will of course have to be carefully considered in designing an implementation program.

Table II presents seven groups of statistical reporting tables plus a sample representation summary. The latter is provided under the assumption that within any SIC category, less than 100% of the industries in that category are likely to report, or that a survey may be based upon a limited sampling within each industrial grouping.

### CONSIDERATIONS RELATED TO SIC

A four-digit SIC is recommended for Division A through D of the Code. Division D - Manufacturing - has a total of about 420 separate four-digit entires. A four-digit listing for Division - Agriculture, Forestry and Fishing, would involve about 64 additional categories. Division D - Construction - has 28 four-digit entires. These four categories totalling about 560 separate entries represent the overwhelming portion of waste sources likely to generate significant quantities of wastes in material categories up to series 80000.

The other SIC major divisions are:

- E. Transportion, Communication, Electric, Gas, and Sanitary Services (41)
- F. Wholesale Trade (29)
- G. Retail Trade (44)

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- H. Finance, Insurance and Real Estate
- I. Services
- J. Public Administration
- K. Non-classifiable establishments

Most of the wastes generated in these divisions are likely to be classified within the 90000 series of materials, as among several characteristic common waste mixtures. A three-digit listing for Division E, F, and G is recommended as adequate for most purposes. The number of three-digit entries for those divisions is indicated in parenthesis above.

Divisions H through K are not sources of industrial wastes. With certain important exceptions, virtually all wastes from these divisions will be in the nature of common office wastes, with no significant variation in the composition of wastes among these categories.

The exceptions would include Major Group 75 - Automotive Repair Services and Garages, Major Group 80 - Health Services which includes hospitals and clinics, and Major Group 84 - Museums, Art Galleries, Botanical and Zoological Gardens.

If Divisions H through K are to be included in the inventory system, it would appear that a two-digit basis for the statistical report would be adequate for most categories, with the exception of those noted above where a three-digit report should be generated.

## ORGANIZATION OF THE STATISTICAL SUMMARIES

Seven groups of possible output tables are each discussed briefly below.

### 1. Thermal Waste Summaries

This series contains information about wastes that leave the industry, by SIC. Thus, if there is an incinerator, ashes will be reported, but no information regarding incinerator input is given. Waste materials in these categories may occur in solid, aqueous, or gaseous waste streams. One option is to report all wastes by weight in tons regardless of phase. Alternatively, sanitary sewage (99000) might be reported in million gallons, waste gases (85000) in million cubic feet and all other wastes in tons.

1. Wastes Generated by Major Material Categories - This table would summarize all wastes generated by each indicated SIC category, and by several major material categories within each of the nine waste material divisions. All wastes might be reported in tons except where otherwise indicated.

2. Destination by Waste Management Entity - This table would indicate the distribution of industrial wastes to the various receiving entities.

3. Distribution by Transportation Mode - This table would indicate how terminal wastes are transported after they leave the plant.

4. Distribution by Final Disposal Method - This table indicates the ultimate fate of terminal wastes. The problem of appropriate units is apparent here, and the units suggested by the table may have to be reconsidered.

5. Quantities of Hazardous Wastes - This table is divided into three parts: A. Solids and Semi-Solids; B. Liquids and Slurries; and C. Gases. Totals are then reported in units appropriate to each phase.

## III. OTHER INDUSTRIAL MANAGEMENT SUMMARIES

This set of tables is also organized to provide tabulated information by SIC code. Information about each industry that appears on the inventory form is statistically accumulated in these tables.

1. Industrial Characteristics Summaries - This is a summary of information contained on Part I of the inventory form. It includes information which does not directly pertain to waste management, but will be of interest to those studying the relationships between waste generation rates and certain other industrial parameters.

2. Waste Inputs to In-Plant Treatment Systems - This table summarizes the utilization of in-plant waste treatment systems. The seven major categories of waste treatment shown on the Table may be expanded to include a more detailed specification of treatment processes within each cateogry.

3. Economics of Waste Treatment - This table summarizes the costs of owning and operating the various types of in-plant treatment systems.

4. Economics of Handling, Transportation, and Disposal - This table provides a summary of what industry is paying for internal handling, removal, and transportation of wastes. Any costs related to waste treatment are specifically excluded from this table. Clearly, there is some possibility of ambiguity in the statistical reporting between Table 3 and 4 that will be difficult to avoid. It would appear, however, that the problem of double entry can be completely avoided, so that the totals of the two tables remain valid.

5. Secondary Materials Consumption - This table provides a summary of what each industry consumes directly in the form of secondary materials. The sample table shows only the nine major waste categories, and can be expanded in a manner to Group I. Table I.

## IV. DETAILED MATERIALS REPORT

These first two groups of tables organized information that was appended to the SIC designation. This set of tables treats information that can be appended to a materials classification.

Materials in the inventory were classified among seven physical forms:

1. Solid
2. Tar
3. Slurry
4. Liquid
5. Sludge
6. Gas
7. Aerosol

Clearly, there is room for ambiguity and inconsistency of judgment regarding the appropriate physical form for many observed waste materials. Such errors in sampling reports, however, may only alter the total for a given material under a stated form such as "solid". It will not alter the total quantity of that material reported in waste streams of all forms.

All units in this set of tables are reported in terms of weight (i.e. tons) rather than in volume units (i.e. gallons or cubic feet). The reason for this is that the table reports on quantities of individual materials, regardless of the form of the mixture in which they occur. Thus, some quantity of liquid oils may appear as solid wastes, while certain solids such as mineral dusts from grinding operations may appear as liquid wastes. Similarly, certain materials which are physically liquid aerosols, or dusts, might appear in the report on gas effluent streams.

## V. HAZARDOUS WASTE REPORTS - BY MATERIAL

This set of tables treats each of the seven categories of major hazardous materials separately. The basic problem here is the issue of how to classify hazardous materials. Most of the literature appends hazards to specific chemicals, recognizing that hazardous attributes may be diminished or amplified as a function of concentration of the material, and the other materials with which it is mixed or dissolved with.

The suggestion is made that information be provided from both points of view. The Group IV tables would contain materials, including their chemical specification, that are known to be hazardous by virtue of their physical, chemical and biological properties. The specific levels of hazard associated with these materials can be found in standard reference books compiling the hazardous properties of industrial materials and will be appended to the inventory forms during processing of the data for computer storage. Of interest here are the quantities of such materials generated and the manner in which they are managed. Thus, these tables provide essentially the pure material hazard point of view, while the mixed materials viewpoint is treated in the following group of tables.

## VI. HAZARDOUS WASTE REPORTS - BY INDUSTRY

Quantities reported in this set of tables will be those of mixtures which have been designated hazardous during the inventory process, or which are judged to be hazardous by some criteria, automated or otherwise, that accounts for both the chemical composition of each material, and the nature of the mixture. At this point in time, there are no rigorous procedures for automatically classifying waste mixtures as to hazardous attributes. Thus, it is anticipated that some degree of judgment and experience by waste managers in each industry will have to prevail for statistical reporting purposes, at least initially.

## VII. LIQUID EFFLUENTS REPORT - TERMINAL DISCHARGES ONLY

The discharge of terminal liquid effluents is of special interest with respect to impact upon the surface water environment. Two tables are suggested here:

1. Sanitary Sewage
2. All Other Liquid Effluents

These tables deal only with certain physical, chemical, and biological properties of liquid discharges under each industry, since information as to how these liquids are managed was provided in other summary reports.

## VIII. TERMINAL WASTE MATERIAL OCCURRENCES

While most industrial waste materials occur as mixtures or in solution with other materials, none of the previous tables have provided an indication of the concentration of the various materials in waste streams. This table summarizes for each material, the number of streams containing that material, and % distribution by concentration.

This table may represent a summary of materials from all industries, or independent reports within any given SIC indication may be generated.

## IX. DETAILED INDUSTRY REPORT

This report would provide a level of detail beyond that indicated in any of the above tables. For each industry, each of the materials appearing in the waste streams would be listed, with a detail breakdown of information divided into two tables.

1. Terminal Waste Report - This report provides a detailed summary for each industry on the disposition of each material that leaves the plant.

2. In-Plant Treatment Report - This report provides detailed information on each treatment process used within each industry. For each such process a summary is provided of the total quantity of materials treated, and the breakdown of materials that occur in the input streams.

SUMMARY REMARKS

The eight groups of tables shown are merely indicative of the range of statistical reporting that is made possible by the classification system that has been presented. Clearly, the format and contents of Exhibit D will require considerable further refinement and analysis prior to actual implementation. Several problems related to definitions, quantity of reporting material, criteria, consistency, overlapping, and other problems common to any effort at rendering vast quantities of complex material into readily understood tabular summaries, will be evident to the reader upon study and reflection. The solution of all of these problems falls beyond the scope of the present effort. The intent here has been to merely demonstrate the potential power of the proposed classification system in its present first version, in terms of the ability to produce hitherto unavilable statistics of vital national interest regarding the management of industrial wastes.

## TABLE

## STATISTICAL REPORTING SUMMARIES

## SAMPLE REPRESENTATION

| SIC | TOTAL NUMBER OF ESTABLISHMENTS | TOTAL VALUE ADDED PRODUCT | % OF ESTABLISHMENTS REPORTING | % OF VALUE ADDED REPRESENTED |
|---|---|---|---|---|

## I TERMINAL WASTE SUMMARIES

### 1. WASTES GENERATED BY MAJOR MATERIAL CATEGORIES

SIC

TOTAL ANNUAL TONS
(excluding sanitary sewage
and waste gases)

10000 METALS
- 11000 FERROUS
  - 11100 BULK
  - 11200 UNPLATED
  - 11300 PLATED
- 12000 NON FERROUS
  - 12100 INDEPENDENT
    - 12101 ALUMINUM
    - 12102 COPPER
    - 12103 LEAD
    - 12104 ZINC
  - 12200 ALLOYS
  - 12300 BULK & COMPOSITE

20000 RESINS, PLASTICS & RUBBERS
- 21000 THERMOPLASTIC RESINS
- 22000 THERMOSETTING RESINS
- 23000 LARGELY RUBBER PRODUCTS

30000 WOOD AND PAPER MATERIALS
- 31000 WOOD PRODUCTS
- 32000 PAPER PRODUCTS
- 33000 COMPOSITES

40000 TEXTILES & RELATED FIBERS
- 41000 NATURAL FIBERS
- 42000 SYNTHETIC FIBERS
- 43000 COMPOSITES

50000 INERT MATERIALS

- 51000 NATURAL GEOLOGIC ORIGIN
- 52000 MAN MADE INERTS
  - 52100 GLASS
  - 52200 NON-GLASS MATERIALS
  - 52300 INDUSTRIAL PROCESS INERTS
- 53000 MISCELLANEOUS MIXES: RUBBLE, ETC.

60000 ANIMAL PRODUCT WASTES

- 61000 ANIMAL PROCESSING WASTES
- 62000 DAIRY WASTES
- 63000 LIVE ANIMAL WASTES
- 64000 COMPOSTS
- 65000 WHOLE DEAD ANIMALS

70000 VEGETATIVE PRODUCT WASTES

80000 CHEMICAL AND BIOCHEMICAL WASTES

- 81000 ORGANIC CHEMICALS
- 82000 INORGANIC CHEMICALS
- 83000 OTHER CHEMICAL PROCESS WASTES
- 84000 CONVENTIONAL PROCESS WASTES
- 85000 WASTE GASES (MILLION CUBIC FEET)

90000 MISCELLANEOUS COMMON WASTE MIXTURES

- 91000 - 98000 ALL COMMON SOLIDS
- 99000 SANITARY SEWAGE (MILLION GALLONS)

## I TERMINAL WASTE SUMMARIES (continued)

### 2. DESTINATION BY WASTE MANAGEMENT ENTITY

(excludes sanitary sewage & waste gases)

| | | | | | |
|---|---|---|---|---|---|
| SIC | ______ | ______ | ______ | ______ | ______ |
| TOTAL ANNUAL TONS | | | | | |
| PUBLIC (01-07) | | | | | |
| INDUST. ASSOC. (08) | | | | | |
| PRIVATE CONTRACTOR (09) | | | | | |
| SALVAGE DEALER (10) | | | | | |
| OTHER INDUSTRY (11) | | | | | |
| SELF DISPOSAL (12) | | | | | |
| OTHER (13) | | | | | |

## I TERMINAL WASTE SUMMARIES (continued)

### 3. DISTRIBUTION BY TRANSPORTATION MODE

(excludes sanitary sewage & waste gases)

| | | | | | |
|---|---|---|---|---|---|
| SIC | ______ | ______ | ______ | ______ | ______ |
| TOTAL ANNUAL TONS | | | | | |
| TRUCK (01) | | | | | |
| RAIL (02) | | | | | |
| SHIP OR BARGE (03) | | | | | |
| PLANE (04) | | | | | |
| SEWER (05) | | | | | |
| RIVER (06) | | | | | |
| RESERVOIR OR LAKE (07) | | | | | |
| OCEAN (08) | | | | | |
| WELL (09) | | | | | |
| AIR (10) | | | | | |
| ON SITE (11) | | | | | |

## I TERMINAL WASTE SUMMARIES (continued)

## 4. DISTRIBUTION BY FINAL DISPOSAL METHOD

| | | | | | |
|---|---|---|---|---|---|
| SIC | ____ | ____ | ____ | ____ | ____ |
| TOTAL ANNUAL TONS | | | | | |
| LANDFILL OR DUMP (01) (TONS) | | | | | |
| OCEAN DUMP (02) (TONS) | | | | | |
| OTHER WATER DUMP (03) (TONS) | | | | | |
| INCINERATE WITH THERMAL RECOVERY (04) (TONS) | | | | | |
| INCINERATE WITHOUT THERMAL RECOVERY (05) (TONS) | | | | | |
| PYROLYZE (06) (TONS) | | | | | |
| HYDROLYZE (07) (TONS) | | | | | |
| COMPOST OR DIGEST (08) (TONS) | | | | | |
| REUSE OR RECYCLE (09) (TONS) | | | | | |
| SEWAGE TREATMENT PROCESS | | | | | |
| LESS THAN PRIMARY (10) (MA) | | | | | |
| PRIMARY (11) (MA) | | | | | |
| SECONDARY (12) (MA) | | | | | |
| TERITIARY (13) (MA) | | | | | |

## I TERMINAL WASTE SUMMARIES (continued)

## 4. DISTRIBUTION BY FINAL DISPOSAL METHOD (continued)

| SIC | | | | | |
|---|---|---|---|---|---|
| OTHER (14) (MA) | | | | | |
| OTHER TREATMENT PROCESS (15) (MA) | | | | | |
| DEEP WELL INJECTION (16) (MA) | | | | | |
| DEEP MINE DISPOSAL (17) (TONS) | | | | | |
| STACK TO ATMOSPHERE (18) MCF) | | | | | |
| OTHER DISPOSAL METHOD (18) (TONS) | | | | | |

## I TERMINAL WASTE SUMMARIES (continued)

### 5. QUANTITIES OF HAZARDOUS WASTES

A. SOLIDS & SEMI-SOLIDS

SIC ____ ____ ____ ____ ____

TOTAL ANNUAL
A. TONS, B. GALLONS,
C. CUBIC FEET

TOTAL HAZARDOUS
TONS

EXPLOSIVE (01)

RADIOACTIVE (02)

PATHOGENIC (03)

CARCINOGENIC (04)

MUTAGENIC (05)

TERATOGENIC (06)

CORROSIVE (07)

FLAMMABLE (08)

TOXIC (09-11)

DESTRUCTIVE OF
PLANT OR ANIMAL
LIFE (12)

OTHERWISE
DANGEROUS (13)

B. LIQUIDS & SLURRIES

C. GAS

## II OTHER INDUSTRIAL MANAGEMENT SUMMARIES

### 1. INDUSTRIAL CHARACTERISTICS SUMMARIES

| | | | | | |
|---|---|---|---|---|---|
| SIC | ____ | ____ | ____ | ____ | ____ |
| NUMBER OF ESTABLISHMENTS | | | | | |
| NUMBER OF RAIL SIDINGS | | | | | |
| NUMBER WITH SHIP OR BARGE ACCESS | | | | | |
| TOTAL SOLIDS (TONS) | | | | | |
| TOTAL SLURRIES & LIQUIDS (GALLONS) | | | | | |
| TOTAL GAS (CF) | | | | | |
| EMPLOYEES | | | | | |
| VALUE ADDED | | | | | |
| WASTER CONSUMPTION | | | | | |
| ELECTRIC CONSUMPTION | | | | | |
| LIQUID FUEL CONSUMPTION | | | | | |
| GASEOUS FUEL CONSUMPTION | | | | | |
| SOLID FUEL CONSUMPTION | | | | | |
| STEAM CONSUMPTION | | | | | |
| TOTAL ENERGY CONSUMPTION | | | | | |

## II OTHER INDUSTRIAL MANAGEMENT SUMMARIES (continued)

### 2. WASTE INPUTS TO IN-PLANT TREATMENT SYSTEMS

SIC ____ ____ ____ ____ ____

HIGH TEMP.
SYSTEMS (3100)
(TONS)

CONC. WASTE
LIQUID SYSTEMS
(3200) (GALLONS)

DILUTE WASTE
WATER SYSTEMS
(3300) (GALLONS

OTHER CHEMICAL
TREATMENT (3400)
(GALLONS)

COMPOST SYSTEMS
(3500) (TONS)

SOLID SEPARATING
SYSTEMS (3600)
(TONS)

WASTE GAS
TREATMENT SYSTEMS
(3700) (CUBIC FEET)

## II OTHER INDUSTRIAL MANAGEMENT SUMMARIES (continued)

## 2. WASTE INPUTS TO IN-PLANT TREATMENT SYSTEMS

SIC ____ ____ ____ ____ ____

| | |
|---|---|
| HIGH TEMP. SYSTEMS (3100) – | A.<br>B.<br>C.<br>D. |
| CONC. WASTE LIQUID SYSTEMS (3200) – | A.<br>:<br>D. |
| DILUTE WASTE WATER SYSTEMS (3300) – | A.<br>:<br>D. |
| OTHER CHEMICAL TREATMENT (3400) – | A.<br>:<br>D. |
| COMPOST SYSTEMS (3500) – | A.<br>:<br>D. |
| SOLID SEPARATING SYSTEMS (3600) – | A.<br>:<br>D. |
| WASTE GAS TREATMENT SYSTEM (3700) – | A.<br>:<br>D. |
| TOTAL – | A.<br>:<br>D. |

| | |
|---|---|
| A. | No. OF UNITS |
| B. | CAP. COSTS |
| C. | OPER. COST |
| D. | % LABOR |

## II OTHER INDUSTRIAL MANAGEMENT SUMMARIES (continued)

### 4. ECONOMICS OF HANDLING, TRANSPORTATION & DISPOSAL

SIC ______ ______ ______ ______ ______

PAYMENTS FOR REMOVAL

INTERNAL HANDLING COSTS

% LABOR

TRANSPORTATION COSTS

SALES OF WASTE BY-PRODUCT

TOTAL

## II OTHER INDUSTRIAL MANAGEMENT SUMMARIES (continued)

### 5. SECONDARY MATERIAL CONSUMPTION

SIC ____ ____ ____ ____ ____

TOTAL ANNUAL
(TONS)____________________
($)____________________

METAL
(TONS)____________________
($)____________________

RESINS, PLASTICS
RUBBER
(TONS)____________________
($)____________________

WOOD & PAPER
(TONS)____________________
($)____________________

TEXTILES &
FIBRES
(TONS)____________________
($)____________________

INERT MATERIALS
(TONS)____________________
($)____________________

VEGET. PRODUCT
WASTES
(TONS)____________________
($)____________________

CHEM. &
BIOCHEM. WASTES
(TONS)____________________
($)____________________

MISC. COMMON
MIXTURES
(TONS)____________________
($)____________________

## III DETAILED MATERIALS REPORT

### 1. SOLID WASTES

| MATERIAL | | | | | | |
|---|---|---|---|---|---|---|
| QUANTITY (TONS) | | | | | | |
| DIRECT % SALVAGED (TABLE VII-10&11) | | | | | | |
| SALVAGE VALUE ($) | | | | | | |
| % INCINERATED BY INDUSTRY (TABLE IV-3100) | | | | | | |
| % INCINERATED EXTERNALLY (TABLE VII-04&05) | | | | | | |
| % LANDFILL (TABLE VII-01) | | | | | | |
| % OCEAN DUMP (-02) | | | | | | |
| % OTHER DUMP (-02) | | | | | | |
| % OTHER WATER DUMP (-03) | | | | | | |
| % PYROLYZED HYDROLIZED OR COMPOSTED (-06-08) | | | | | | |
| % REUSED OR RECYCLED (-09) | | | | | | |
| % DEEP MINE DISPOSAL (-17) | | | | | | |

## III DETAILED MATERIALS REPORT (continued)

### 2. TARS

| MATERIAL | | | | | | |
|---|---|---|---|---|---|---|
| QUANTITY (TONS) | | | | | | |
| DIRECT % SALVAGED (TABLE VII-10&11) | | | | | | |
| SALVAGE VALUE ($) | | | | | | |
| % INCINERATED BY INDUSTRY (TABLE IV-3100) | | | | | | |
| % INCINERATED EXTERNALLY (TABLE VII-04405) | | | | | | |
| % LANDFILL (TABLE VII-01) | | | | | | |
| % OCEAN DUMP (-02) | | | | | | |
| % OTHER WATER DUMP (-03) | | | | | | |
| % PYROLYZED OR HYDROLYZED COMPOSTED (-06-08) | | | | | | |
| % REUSED OR RECYCLED (-09) | | | | | | |
| % DEEP MINE DISPOSAL (-17) | | | | | | |

## III DETAILED MATERIALS REPORT (continued)

### 3. SLURRIES

MATERIAL ______ ______ ______ ______ ______ ______

QUANTITY (TONS)

DIRECT % SALVAGED (TABLE VII-10&11)

SALVAGE VALUE ($)

% INCINERATED BY INDUSTRY (TABLE IV-3100)

% INCINERATED EXTERNALLY (TABLE VII-04405)

% LANDFILL (TABLE VII-01)

% OCEAN DUMP (-02)

% OTHER WATER DUMP (-03)

% PYROLYZED HYDROLYZED OR COMPOSTED (-06-08)

% REUSED OR RECYCLED (-09)

% DEEP MINE DISPOSAL (-17)

DISCHARGED AS SEWAGE

LESS THAN PRIMARY (VII-10)

PRIMARY (VII-11)

SECONDARY (VII-12)

TERTIARY (VII-13)

OTHER (VII-14)

## III DETAILED MATERIALS REPORT (continued)

### 4. LIQUIDS

| MATERIAL | | | | | | |
|---|---|---|---|---|---|---|
| QUANTITY (TONS) | | | | | | |
| DIRECT % SALVAGED (TABLE VII-10&11) | | | | | | |
| SALVAGE VALUE ($) | | | | | | |
| % INCINERATED BY INDUSTRY (TABLE IV-3100) | | | | | | |
| % INCINERATED EXTERNALLY (TABLE VII-04405) | | | | | | |
| % LANDFILL (TABLE VII-01) | | | | | | |
| % OCEAN DUMP (-02) | | | | | | |
| % OTHER WATER DUMP (-03) | | | | | | |
| % PYROLYZED HYDROLYZED OR COMPOSTED (-06-08) | | | | | | |
| % REUSED OR RECYCLED (-09) | | | | | | |
| % DEEP MINE DISPOSAL (-17) | | | | | | |
| **DISCHARGED AS SEWAGE** | | | | | | |
| LESS THAN PRIMARY (VII-10) | | | | | | |
| PRIMARY (VII-11) | | | | | | |
| SECONDARY (VII-12) | | | | | | |
| TERTIARY (VII-13) | | | | | | |
| OTHER (VII-14) | | | | | | |

## III DETAILED MATERIALS REPORT (continued)

### 5. GAS

| | | | | | | |
|---|---|---|---|---|---|---|
| MATERIAL | | | | | | |
| QUANTITY (TONS) | | | | | | |
| % DIRECT SALVAGED | | | | | | |
| SALVAGE VALUE | | | | | | |
| % TREATED (IV-3700) | | | | | | |
| % TO ATMOSPHERE (VIII-18) | | | | | | |

## IV HAZARDOUS WASTE REPORTS - BY MATERIAL

### 1. EXPLOSIVE

MATERIAL CATEGORY ______ ______ ______ ______ ______

CHEMICAL CATEGORY

QUANTITY

% TREATED IN PLANT

% CONTAINERIZED OR TANKED

% MANUALLY HANDLED

% TRANSPORTED BY TRUCK

% TRANSPORTED BY RAIL

% TRANSPORTED BY SHIP

% TRANSPORTED BY PLANE

% LANDFILL

% OCEAN DUMP

% OTHER WATER DUMP

% INCINERATED OR PYROLYZED

% DEEP WELL INJECTION

% DEEP MINE DISPOSAL

## IV HAZARDOUS WASTE REPORTS (continued)

### 2. RADIOACTIVE

MATERIAL CATEGORY ______ ______ ______ ______ ______ ______

CHEMICAL CATEGORY

QUANTITY

% TREATED IN PLANT

% CONTAINERIZED OR TANKED

% MANUALLY HANDLED

% TRANSPORTED BY TRUCK

% TRANSPORTED BY RAIL

% TRANSPORTED BY SHIP

% TRANSPORTED BY PLANE

% LANDFILL

% OCEAN DUMP

% OTHER WATER DUMP

% INCINERATED OR PYROLYZED

% DEEP WELL INJECTION

% DEEP MINE DISPOSAL

## IV HAZARDOUS WASTE REPORTS (continued)

### 3. PATHOGENIC

| | | | | | | |
|---|---|---|---|---|---|---|
| MATERIAL CATEGORY | ____ | ____ | ____ | ____ | ____ | ____ |
| CHEMICAL CATEGORY | | | | | | |
| QUANTITY | | | | | | |
| % TREATED IN PLANT | | | | | | |
| % CONTAINERIZED OR TANKED | | | | | | |
| % MANUALLY HANDLED | | | | | | |
| % TRANSPORTED BY TRUCK | | | | | | |
| % TRANSPORTED BY RAIL | | | | | | |
| % TRANSPORTED BY SHIP | | | | | | |
| % TRANSPORTED BY PLANE | | | | | | |
| % LANDFILL | | | | | | |
| % OCEAN DUMP | | | | | | |
| % OTHER WATER DUMP | | | | | | |
| % INCINERATED OR PYROLYZED | | | | | | |
| % DEEP WELL INJECTION | | | | | | |
| % DEEP MINE DISPOSAL | | | | | | |

## IV HAZARDOUS WASTE REPORTS (continued)

### 4. MUTAGENIC, CARCINOGENIC OR TERATOGENIC

MATERIAL CATEGORY ______ ______ ______ ______ ______ ______

CHEMICAL CATEGORY

QUANTITY

% TREATED IN PLANT

% CONTAINERIZED OR TANKED

% MANUALLY HANDLED

% TRANSPORTED BY TRUCK

% TRANSPORTED BY RAIL

% TRANSPORTED BY SHIP

% TRANSPORTED BY PLANE

% LANDFILL

% OCEAN DUMP

% OTHER WATER DUMP

% INCINERATED OR PYROLYZED

% DEEP WELL INJECTION

% DEEP MINE DISPOSAL

## IV HAZARDOUS WASTE REPORTS (continued)

### 5. FLAMMABLE

MATERIAL CATEGORY ____ ____ ____ ____ ____ ____

CHEMICAL CATEGORY

QUANTITY

% TREATED IN PLANT

% CONTAINERIZED OR TANKED

% MANUALLY HANDLED

% TRANSPORTED BY TRUCK

% TRANSPORTED BY RAIL

% TRANSPORTED BY SHIP

% TRANSPORTED BY PLANE

% LANDFILL

% OCEAN DUMP

% OTHER WATER DUMP

% INCINERATED OR PYROLYZED

% DEEP WELL INJECTION

% DEEP MINE DISPOSAL

## IV HAZARDOUS WASTE REPORTS (continued)

### 6. TOXIC TO HUMANS

MATERIAL CATEGORY ______ ______ ______ ______ ______ ______

CHEMICAL CATEGORY

QUANTITY

% TREATED IN PLANT

% CONTAINERIZED OR TANKED

% MANUALLY HANDLED

% TRANSPORTED BY TRUCK

% TRANSPORTED BY RAIL

% TRANSPORTED BY SHIP

% TRANSPORTED BY PLANE

% LANDFILL

% OCEAN DUMP

% OTHER WATER DUMP

% INCINERATED OR PYROLYZED

% DEEP WELL INJECTION

% DEEP MINE DISPOSAL

## IV HAZARDOUS WASTE REPORTS (continued)

### 7. OTHERWISE HARMFUL TO ENVIRONMENT

| | | | | | | |
|---|---|---|---|---|---|---|
| MATERIAL CATEGORY | | | | | | |
| CHEMICAL CATEGORY | | | | | | |
| QUANTITY | | | | | | |
| % TREATED IN PLANT | | | | | | |
| % CONTAINERIZED OR TANKED | | | | | | |
| % MANUALLY HANDLED | | | | | | |
| % TRANSPORTED BY TRUCK | | | | | | |
| % TRANSPORTED BY RAIL | | | | | | |
| % TRANSPORTED BY SHIP | | | | | | |
| % TRANSPORTED BY PLANE | | | | | | |
| % LANDFILL | | | | | | |
| % OCEAN DUMP | | | | | | |
| % OTHER WATER DUMP | | | | | | |
| % INCINERATED OR PYROLYZED | | | | | | |
| % DEEP WELL INJECTION | | | | | | |
| % DEEP MINE DISPOSAL | | | | | | |

## V HAZARDOUS WASTE REPORTS - BY INDUSTRY

### 1. EXPLOSIVE

| SIC | | | | | | |
|---|---|---|---|---|---|---|
| QUANTITY | | | | | | |
| % TREATED IN PLANT | | | | | | |
| % CONTAINERIZED OR TANKED | | | | | | |
| % MANUALLY HANDLED | | | | | | |
| % TRANSPORTED BY TRUCK | | | | | | |
| % TRANSPORTED BY RAIL | | | | | | |
| % TRANSPORTED BY SHIP | | | | | | |
| % TRANSPORTED BY PLANE | | | | | | |
| % LANDFILL | | | | | | |
| % OCEAN DUMP | | | | | | |
| % OTHER WATER DUMP | | | | | | |
| % INCINERATED OR PYROLYZED | | | | | | |
| % DEEP WELL INJECTION | | | | | | |
| % DEEP MINE DISPOSAL | | | | | | |

## V HAZARDOUS WASTE REPORTS - BY INDUSTRY

### 2. RADIOACTIVE

| SIC | | | | | | |
|---|---|---|---|---|---|---|
| QUANTITY | | | | | | |
| % TREATED IN PLANT | | | | | | |
| % CONTAINERIZED OR TANKED | | | | | | |
| % MANUALLY HANDLED | | | | | | |
| % TRANSPORTED BY TRUCK | | | | | | |
| % TRANSPORTED BY RAIL | | | | | | |
| % TRANSPORTED BY SHIP | | | | | | |
| % TRANSPORTED BY PLANE | | | | | | |
| % LANDFILL | | | | | | |
| % OCEAN DUMP | | | | | | |
| % OTHER WATER DUMP | | | | | | |
| % INCINERATED OR PYROLYZED | | | | | | |
| % DEEP WELL INJECTION | | | | | | |
| % DEEP MINE DISPOSAL | | | | | | |

## V HAZARDOUS WASTE REPORTS - BY INDUSTRY

### 3. PATHOGENIC

SIC ________ ________ ________ ________ ________ ________

QUANTITY

% TREATED IN PLANT

% CONTAINERIZED OR TANKED

% MANUALLY HANDLED

% TRANSPORTED BY TRUCK

% TRANSPORTED BY RAIL

% TRANSPORTED BY SHIP

% TRANSPORTED BY PLANE

% LANDFILL

% OCEAN DUMP

% OTHER WATER DUMP

% INCINERATED OR PYROLYZED

% DEEP WELL INJECTION

% DEEP MINE DISPOSAL

## V HAZARDOUS WASTE REPORTS - BY INDUSTRY

### 4. MUTAGENIC, CARCINOGENIC OR TERATOGENIC

| | | | | | | |
|---|---|---|---|---|---|---|
| **SIC** | | | | | | |
| QUANTITY | | | | | | |
| % TREATED IN PLANT | | | | | | |
| % CONTAINERIZED OR TANKED | | | | | | |
| % MANUALLY HANDLED | | | | | | |
| % TRANSPORTED BY TRUCK | | | | | | |
| % TRANSPORTED BY RAIL | | | | | | |
| % TRANSPORTED BY SHIP | | | | | | |
| % TRANSPORTED BY PLANE | | | | | | |
| % LANDFILL | | | | | | |
| % OCEAN DUMP | | | | | | |
| % OTHER WATER DUMP | | | | | | |
| % INCINERATED OR PYROLYZED | | | | | | |
| % DEEP WELL INJECTION | | | | | | |
| % DEEP MINE DISPOSAL | | | | | | |

## V HAZARDOUS WASTE REPORTS - BY INDUSTRY

### 5. FLAMMABLE

| SIC | | | | | | |
|---|---|---|---|---|---|---|
| QUANTITY | | | | | | |
| % TREATED IN PLANT | | | | | | |
| % CONTAINERIZED OR TANKED | | | | | | |
| % MANUALLY HANDLED | | | | | | |
| % TRANSPORTED BY TRUCK | | | | | | |
| % TRANSPORTED BY RAIL | | | | | | |
| % TRANSPORTED BY SHIP | | | | | | |
| % TRANSPORTED BY PLANE | | | | | | |
| % LANDFILL | | | | | | |
| % OCEAN DUMP | | | | | | |
| % OTHER WATER DUMP | | | | | | |
| % INCINERATED OR PYROLYZED | | | | | | |
| % DEEP WELL INJECTION | | | | | | |
| % DEEP MINE DISPOSAL | | | | | | |

## V HAZARDOUS WASTE REPORTS - BY INDUSTRY

### 6. TOXIC TO HUMANS

| SIC | ______ | ______ | ______ | ______ | ______ | ______ |
|---|---|---|---|---|---|---|
| QUANTITY | | | | | | |
| % TREATED IN PLANT | | | | | | |
| % CONTAINERIZED OR TANKED | | | | | | |
| % MANUALLY HANDLED | | | | | | |
| % TRANSPORTED BY TRUCK | | | | | | |
| % TRANSPORTED BY RAIL | | | | | | |
| % TRANSPORTED BY SHIP | | | | | | |
| % TRANSPORTED BY PLANE | | | | | | |
| % LANDFILL | | | | | | |
| % OCEAN DUMP | | | | | | |
| % OTHER WATER DUMP | | | | | | |
| % INCINERATED OR PYROLYZED | | | | | | |
| % DEEP WELL INJECTION | | | | | | |
| % DEEP MINE DISPOSAL | | | | | | |

## V HAZARDOUS WASTE REPORTS - BY INDUSTRY

### 7. OTHERWISE HARMFUL TO ENVIRONMENT

| SIC | | | | | | |
|---|---|---|---|---|---|---|
| QUANTITY | | | | | | |
| % TREATED IN PLANT | | | | | | |
| % CONTAINERIZED OR TANKED | | | | | | |
| % MANUALLY HANDLED | | | | | | |
| % TRANSPORTED BY TRUCK | | | | | | |
| % TRANSPORTED BY RAIL | | | | | | |
| % TRANSPORTED BY SHIP | | | | | | |
| % TRANSPORTED BY PLANE | | | | | | |
| % LANDFILL | | | | | | |
| % OCEAN DUMP | | | | | | |
| % OTHER WATER DUMP | | | | | | |
| % INCINERATED OR PYROLYZED | | | | | | |
| % DEEP WELL INJECTION | | | | | | |
| % DEEP MINE DISPOSAL | | | | | | |

## VI LIQUID EFFLUENTS REPORT - TERMINAL DISCHARGES ONLY

### 1. SANITARY SEWAGE - III-90000 ONLY

| SIC | | | | | | |
|---|---|---|---|---|---|---|
| QUANTITY (MIL. GALS.) | | | | | | |
| % WITH BOD REPORT | | | | | | |
| TOTAL BOD (TONS) | | | | | | |
| % WITH COD REPORT | | | | | | |
| TOTAL COD (TONS) | | | | | | |
| % WITH SS REPORT | | | | | | |
| TOTAL SS (TONS) | | | | | | |
| % WITH DS REPORT | | | | | | |
| TOTAL DS (TONS) | | | | | | |
| % REPORTING pH | | | | | | |
| % WITH pH < 3 | | | | | | |
| % WITH pH=3-6 | | | | | | |
| % WITH pH=6-8 | | | | | | |
| $ WITH pH=8-10 | | | | | | |
| % WITH pH >10 | | | | | | |
| % WITH COLIFORMS EXCEEDING ___MPN/ML | | | | | | |

## VI LIQUID EFFLUENTS REPORT - TERMINAL DISCHARGES ONLY (continued)

### 2. ALL OTHER LIQUID EFFLUENTS

SIC ________ ________ ________ ________ ________ ________

QUANTITY
(MIL. GALS.)

% WITH BOD
REPORT

TOTAL BOD
(TONS)

% WITH COD
REPORT

TOTAL COD
(TONS)

% WITH SS
REPORT

TOTAL SS
(TONS)

% WITH DS
REPORT

TOTAL DS
(TONS)

% REPORTING
pH

% WITH pH < 3

% WITH pH=3-6

% WITH pH=6-8

$ WITH pH=8-10

% WITH pH >10

% WITH COLIFORMS
EXCEEDING ___MPN/ML

## VII TERMINAL WASTE MATERIAL OCCURRENCES

| MATERIAL | | | | | | |
|---|---|---|---|---|---|---|
| NUMBER OF STREAMS CONTAINING MATERIAL | | | | | | |
| TOTAL STREAM QUANTITY (TONS) | | | | | | |
| % OF STREAMS WITH MATERIAL COMPONENT: | | | | | | |
| TRACE | | | | | | |
| <5% | | | | | | |
| 5-10% | | | | | | |
| 10-20% | | | | | | |
| 20-30% | | | | | | |
| 30-40% | | | | | | |
| 40-50% | | | | | | |
| 50-60% | | | | | | |
| 60-70% | | | | | | |
| 70-80% | | | | | | |
| 80-90% | | | | | | |
| 90-100% | | | | | | |

## VIII DETAILED INDUSTRY REPORT

SIC = ____________

### 1. TERMINAL WASTE REPORT

| MATERIAL | ______ | ______ | ______ | ______ | ______ | ______ |
|---|---|---|---|---|---|---|
| TOTAL TERMINAL | | | | | | |
| **RECEIVING ENTITY** | | | | | | |
| PUBLIC | | | | | | |
| INDUST. ASSOC. | | | | | | |
| PRIV. CONTR. | | | | | | |
| SALVAGE DEALER | | | | | | |
| OTHER INDUST. | | | | | | |
| SELF | | | | | | |
| **METHOD OF SHIPMENT** | | | | | | |
| TRUCK | | | | | | |
| RAIL | | | | | | |
| BARGE | | | | | | |
| PLANE | | | | | | |
| SEWER | | | | | | |
| DIRECT DISCHARGE TO ENVIRONMENT | | | | | | |

## VIII DETAILED INDUSTRY REPORT

### 1. TERMINAL WASTE REPORT (continued)

MATERIAL ________ ________ ________ ________ ________ ________

FINAL DISPOSITION

LANDFILL

OCEAN

OTHER WATER

INCINERATE THERMAL RECOVERY

INCINERATE NO THERMAL RECOVERY

PYROLYZE
HYDROLYZE
COMBUST OR DIGEST

TREAT AS SEWAGE

LESS THAN PRIMARY

PRIMARY

SECONDARY

TERTIARY

---

DEEP WELL INJECTION

DEEP MINE

STACK

## VIII DETAILED INDUSTRY REPORT

### 2. IN-PLANT TREATMENT REPORT

PROCESS
(SERIES 3100-3700
OF TABLE IV)

TOTAL NUMBER
OF UNITS

TOTAL WASTE
INPUT

MATERIAL INPUTS

MATERIAL CODE

QUANTITY

MATERIAL CODE

QUANTITY

ETC.